NASW-2558

ECON
INCORPORATED

419 NORTH HARRISON STREET
PRINCETON, NEW JERSEY 08540
Telephone 609-924-8778

(NASA-CR-141044) IMPROVED (ERTS) INFORMATION AND ITS IMPACT ON U.S. MARKETS FOR AGRICULTURAL COMMODITIES: A QUANTITIATIVE (ECON, Inc., Princeton, N.J.) 154 p HC $6.25 CSCL 05B

N75-12424

Unclas
G3/43 04687

☐ ECONOMIC ANALYSES ☐ OPERATIONS RESEARCH ☐ POLICY STUDIES ☐ SYSTEMS ANALYSES ☐ TECHNOLOGY ASSESSMENT

ECON
INCORPORATED

419 NORTH HARRISON STREET
PRINCETON, NEW JERSEY 08540
Telephone 609-924-8778

74-2001-6

IMPROVED (ERTS) INFORMATION AND ITS IMPACT ON U.S. MARKETS FOR AGRICULTURAL COMMODITIES: A QUANTITATIVE ECONOMIC INVESTIGATION OF PRODUCTION, DISTRIBUTION AND NET EXPORT EFFECTS

Prepared for
Office of Applications
NASA

Under Contract
NASW-2558

October 31, 1974

IMPROVED (ERTS) INFORMATION AND ITS IMPACT ON U.S. MARKETS FOR AGRICULTURAL COMMODITIES: A QUANTITATIVE ECONOMIC INVESTIGATION OF PRODUCTION, DISTRIBUTION AND NET EXPORT EFFECTS

Prepared by

ECON, INC.

Directed by

Andrew D. Seidel

Andrew D. Seidel, Senior Economist

Approved by

Klaus P. Heiss

Klaus P. Heiss, President

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (Continued)

I. INTRODUCTION

A. Overview

In recent years, the prices of agricultural products have fluctuated widely. In part, these price movements have been the result of general inflationary pressures that have plagued the economy since the late sixties. A significant portion of these price movements, however, is the result of other structural shifts in the economy. Paramount among these other considerations is the increased exposure of American agricultural supplies to foreign demand. Owing to the imprecision surrounding expected foreign demand for American agricultural products, the domestic market has been caught off balance on numerous occasions. Notable among these occasions have been the Russian Wheat deals of the early sixties and seventies. As a result of the increased demand pressures, the U.S. markets for agricultural commodities have shown an increased sensitivity to domestic and foreign crop production projections. The corn blight scare in 1971, for example, drove corn prices up by over 30% in a few months before more accurate information reversed the surge and prices retreated to their prescare levels.

Although many such examples of market response to increased demand pressures and imprecise information can be found, each episode is sufficiently different to deny the formulation of a hard and fast bromide to combat any such future episodes. The reason for this apparent intractability when viewed in the large, lies in the structure of the commodities markets and the multichanneled economic dialogue that takes place within them. When approached as a single message, the signal from the commodities markets may easily be misconstrued as just so much noise. In fact, the activity of the commodities markets is a logically structured process of rational economic behavior.

Commodities such as wheat are traded in two different, but interdependent, markets - the cash (spot) market and the forward sales (futures) market. Commodities in the spot market are traded primarily by those who produce, market, or process foods. The spot market is "cross-sectional", as opposed to "temporal", in that the role of the market process is to allocate existing supplies across existing demands at a point in time. The futures market serves to allocate supplies to demands over time. Commodities in the futures market are traded by both hedgers and speculators. Hedgers, on the one hand, tend to be owners of physical stocks that may sell forward (hedge short) in order to protect their inventories from an unexpected price decline, or may buy forward (hedge long) to cover a future commitment to sell. Speculators, on the other hand, may or may not own physical stocks and sell or buy forward (speculate short or long, respectively) in anticipation of reaping profits from a possible rise or fall in prices beyond what the market currently expects. Hedgers often take a position in the futures market opposite to their cash position and may be viewed as traders in futures with access to the cash market. Thus, the cash and futures market are closely related through the dual market activities of hedgers.

To the extent that the spot and futures markets have accurate information, the market process in a free economy will distribute resources efficiently across uses and over time. Obversely, unexpected surges in demand or unusually poor production forecasts will lead to inefficient resource allocations. Reporting delays, weather aberations etc. introduce inprecision and risk into both the spot and future markets. In the futures markets especially, the "risks" associated with forward contracting have been cited as grounds for absolution of forward markets owing to possible price instabilities arising from the unscrupulous actions of some speculators. Paradoxically, it is the risk and uncertainty surrounding the future that gives rise to the "social" benefits from a well developed futures market. These benefits in the futures market are the lowered costs of production, marketing, and processing owing to the redistribution of risk away from producers, processors, etc., to those willing to invest in assets with an uncertain future value. The consumer in turn may benefit from lowered spot prices.

To be sure, any system may be abused by violating its operating rules. Our purpose here is not to assess the relative immunity of different market processes from possible abuse. Rather, our purpose here is to develop an understanding of how the spot and futures markets for agricultural commodities operate and interact, with special emphasis on the impact of crop forecast information and international trade on the coordination of the United States agricultural commodities markets and to estimate the benefits to society from improved crop forecast information.

B. Problem Statement

At the heart of commodity price determination is the accuracy with which future demands and supplies can be foreseen. Here, two types of information are of special importance to the coordination of domestic commodity markets: the accuracy of domestic crop projections and the accuracy of net export forecasts.

Even when foreign net exports are not a large percentage of domestic harvests and/or stocks, the information about their likely future profile is markedly less available, accurate and timely than similar information about future domestic demands and supplies. For this reason, it has been argued that net exports often have a large disturbing influence on domestic spot and futures price movements. In a similar vein, the more accurate are domestic crop projections, the more efficient (coordinated) the intertemporal distribution of supplies to meet likely demands. Insofar as more accurate crop projections improve market efficiency, and improved market efficiency reflected by an appropriately altered set of prices, improved is information will be reflected in market prices. Reflection, however, is not synonymous with useful understanding. Moreover, improvements may have occurred in domestic crop forecasts, yet the impact on prices may have been masked by contemporaneous, but unrelated, institutional shifts and/or other factors.

The purpose of this study is fourfold. First, to specify the general interdependent structure of the spot and futures markets in an effort better to understand the market process and the factors influencing it. Second, to measure the impact of crop forecast improvement and net export demand on domestic prices. Third, to develop an empirically supported formulation from which to assess the benefits accruing to society from improved crop projections. Finally to develop an empirically supported formulation from which to assess government agricultural policy actions.

C. Scope of Work

This study, of course, cannot attempt to tie together the myriad intricacies of the U.S. spot and futures markets for agricultural commodities. Our aim instead is to use Occam's razor judiciously to structure our effort in such a way as to satisfy our goals without introducing large errors and at the same time keeping a watchful eye on the tractability of our construct. With this as our principal operating thesis, we have adopted the following conventions.

First, we follow Samuelson [72] and develop aggregate structures between groups built up from reasoning about individuals. That is not to say that our constructs may be viewed with complete disregard of the differences between "macro" and "micro" patterns of behavior. Rather, it is to say that market demand and supply structures can be formulated from the tenets of microeconomic theory and provide fruitful results without serious problems of aggregation.

Second, a commodity is treated as homogeneous. That is, no distinction is made as to the type of wheat or type of soybean and differences in their nutritional values. These differences, though they exist, and ultimately are important, are secondary to the main objectives of this study.

Third, foreign demand or supply are combined into net exports and no attempt is made to develop separate models for different regions or countries. That is not to say that the present model does not consider factors that are dependent on origin-destination pairs, such as transportation costs and per capita food production. Rather, it is to say that these factors will be treated as exogeneous to the mainstream of the analysis.

Fourth, in order to shed light on the structural differences between long and short-run movements in commodity prices, the empirical models distinguish between trend/cycle and seasonal relationships.

Fifth, with minor exceptions, the structural relationships are linear, either as a direct statement or as an approximation to a higher order relationship.

Sixth, the behavioral relationships contain a stochastic residual variable reflecting the net influence of neglected variables, measurement errors, and the randomness in human response or some combination of these factors. These variables are assumed to be independent of the variables determined outside the model, independent of each other, and to have stationary distributions over time.

D. Organization of The Study

The paper is organized as follows: In Section II, we summarize our modeling efforts, policy conclusions, and recommendations for further research. In Section III, we present our general model of the domestic spot and futures markets for a commodity. Here, the role of expectations, information, and net exports is set forth in the supply and demand structures describing these markets. Our empirical results are presented in Section IV. For this preliminary investigation, we focused on domestic spot and futures markets for wheat and soybeans. Estimates of potential ERTS benefits to society and selected policy issues are discussed in Section V. Included here are estimates of the annual benefits of improved crop forecast information on soybeans and wheat and how these improvements may effect government agricultural policies. In Section VI, we present our general conclusions and recommendations for further research. Finally, a selected set of references is presented in the Bibliography.

II. EXECUTIVE SUMMARY

Our econometric investigation into the markets for agricultural commodities is summarized here in three parts. The first part is an overview of the effort including the objectives, scope, and architecture of the analysis and the estimation strategy employed. Second, the major empirical results and policy conclusions are set forth. These results and conclusions focus on the economic importance of improved crop forecasts, U.S. exports, and government policy oeprations. Finally, a number of promising avenues of further investigation are suggested.

A. A Model of The Commodities Markets

1. Purpose and Structure

There were four general objectives of this study:

- To specify the general structure of the agricultural commodities markets in order to better understand the market process with special emphasis on the influence of crop forecast information and foreign trade.
- To measure the influence of crop forecasts and net export demand on domestic agricultural commodity prices.

- To develop an empirically supported structure from which to assess the market impacts of government policy actions.
- To provide information needed to weigh the benefits of improved crop projections to society, and to identify linkages and guidelines for an analysis of the world commodity markets.

The study, of course, did not attempt to tie together the myriad intricacies of the U.S. spot and futures markets in order to resolve the above issues in minute detail. Data considerations alone rule out such an ambitious task. Recognizing the empirical constraints on our mission, our research strategy was aimed at robust findings and conclusions about major issues, leaving more detailed analyses of secondary issues for some future study. With this operating thesis in mind, we integrated the three major analytical dimensions of the study without loosing sight of our empirical imperative. The three analytical dimensions at the core of the study are:

- The basic market influences and their avenues of introduction. Here, the principal task was to identify the various factors acting through supply, demand, and general economic conditions on the spot and futures markets.

- The principal behavioral hypotheses and institutional characteristics. These relationships and analytic constructs tie together the various market influences into a formal portrait of the agricultural commodities markets.
- The distinction between long- and short-run decisions and patterns of market behavior. This distinction is crucial in order to weigh properly the impacts and incidence of exogenous influences on the commodities markets.

With respect to the first dimension, the market factors studied included domestic consumption, net exports, government stockpiling, domestic and foreign production, stock adjustments in the private sector, government parity price operations, commodity substitutes and complements, and general economic conditions such as the availability of credit and the rates of inflation on commodities and farm production items.

Naturally, the factors influencing demand and supply were set forth separately for the spot and futures markets. Although both markets have many factors in common, there are three notable exceptions that warrant some comment here. First, the futures market, unlike the spot market, is subject to institutional constraints on market price fluctuations. Secondly, the spot market is concerned with the spatial distribution of known supplies among current demands while the futures market is concerned with the intertemporal distribution of unknown but expected future supplies against expected future demands. Thus, factors influencing expectations, such as crop forecasts, will have a primary effect in the futures market but an indirect effect in the spot market. Third, futures contracts entered into may not be covered. That is, each futures contract entered into may not be matched by an equal and offsetting futures contract or fulfilled by delivery.

These characteristics make an analytical distinction between the spot and futures markets imperative. To be sure, the two markets are interactive since future purchases or sales may be viewed as substitutes or complements for current purchases or sales. However, some "staging" of the commodities markets is necessary; not only to get a clear picture of how and when the various market participants react to, or influence, the actions of others, but also for the tractability of the model.

The behavioral hypotheses invoked to tie together the various market factors into a portrait of the commodities markets fall into two broad categories: general economic concepts that are not intrinsic to the commodities markets and constructs specific to these markets. The general assumptions include the following:

- Investment decisions are based on both return and risk considerations.
- Intertemporal decisions are based in part on on expectations and these expectations may be influenced by known technical forecasts of physical outcomes.
- The rate of change in prices is determined by imbalances between supply and demand.
- Future values are discounted back to the present.

The hypotheses intrinsic to the commodities markets include:

- Futures prices on average tend to be reliable estimates of what should be expected on the basis of available information concerning present and future demand and supply. However, these prices may not reflect market expectations at each point in time owing to technical rigidities in the markets' response to changes in information on supply and demand prospects.
- Futures prices change in response to market imbalances between short hedging and long speculation.

- Intertemporal price spreads reflect, in part, the costs of storage and decay.

Finally, with regard to the third dimension, we assumed:

- The causal structures of long-run patterns of behavior are distinct from their short-run counterparts.

Within this framework, the number of possible analytical constellations or specific models that can be constructed is enormous. Moreover, as illustrated in Figure II.1, the number of interactions contained in any one collection of hypothesized structures, factors, etc., is formidable. As can be seen, each of the major dimensions or axes is further resolved leading to a virtual "curse of dimensionality".

In keeping with our operating thesis, the myriad possible relationships have been combined into more general constructs that transmit the major analytical dialogue between the various market forces and factors. It is from these foundations that the empirical effort was launched.

The product of our blending of behavioral hypotheses and market influences is summarized in a sizeable set of equations, identities, and constraints. The full simultaneous interaction of this model is set forth in the main body of the study and a detailed redescription is beyond the scope of this section.

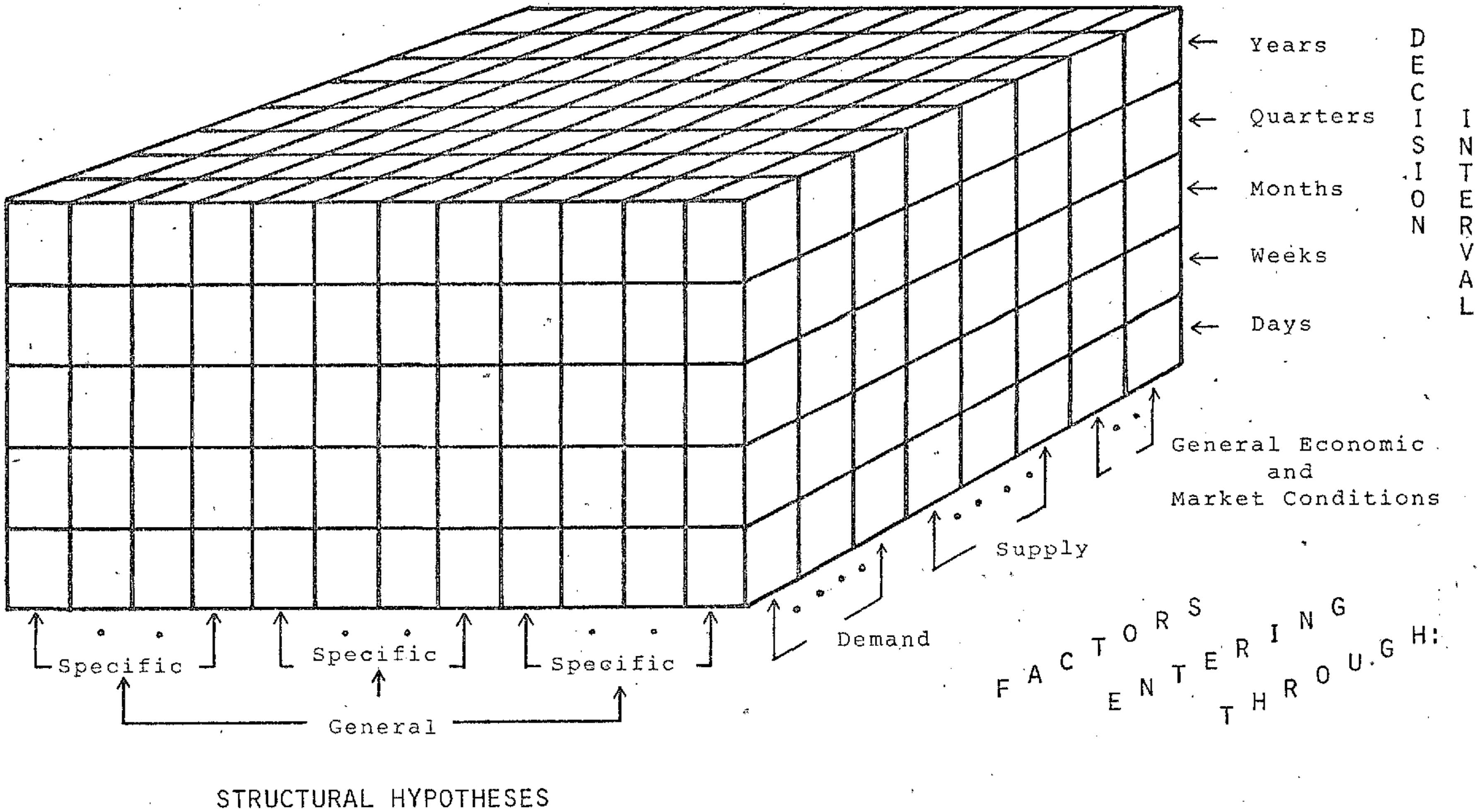


Figure II.1 Illustrative Interactions in a Model From a Constellation of Possible Models.

However, the dominant characteristics of the model are portrayed in the flow diagram presented in Figure II.2. Here, the principal structural linkages and directions of causality that define the architecture of the model are illustrated. The lines connecting the major variables of interest indicate the structural linkages, and the arrows denote the major directions of influence or causality. The simultaneity of the model can be verified by starting at any point (variable) in the mainstream of the model (any one of those variables determined within the model) and following the arrows full course through the model back to the starting point.

For the most part, the flow diagram does not illustrate the numerous exogenous influences that feed the various structures. The exceptions to this pedagogical stylistic are the major "policy" variables. These variables are government exports, GS_q, government domestic purchases $G^{(+)}$ for sales $G^{(-)}$, G_q, and United States Department of Agriculture crop production forecasts, G.

In Figure II.3, the analytical "bottom line" of the model is illustrated with respect to the major policy variables. The dotted lines represent indirect connections between the associated variables. The solid lines denote direct impacts free of intermediate actions and transformations. As can be seen, factors influencing net private exports influence current spot, or cash, prices as do government CCC loans, purchases,

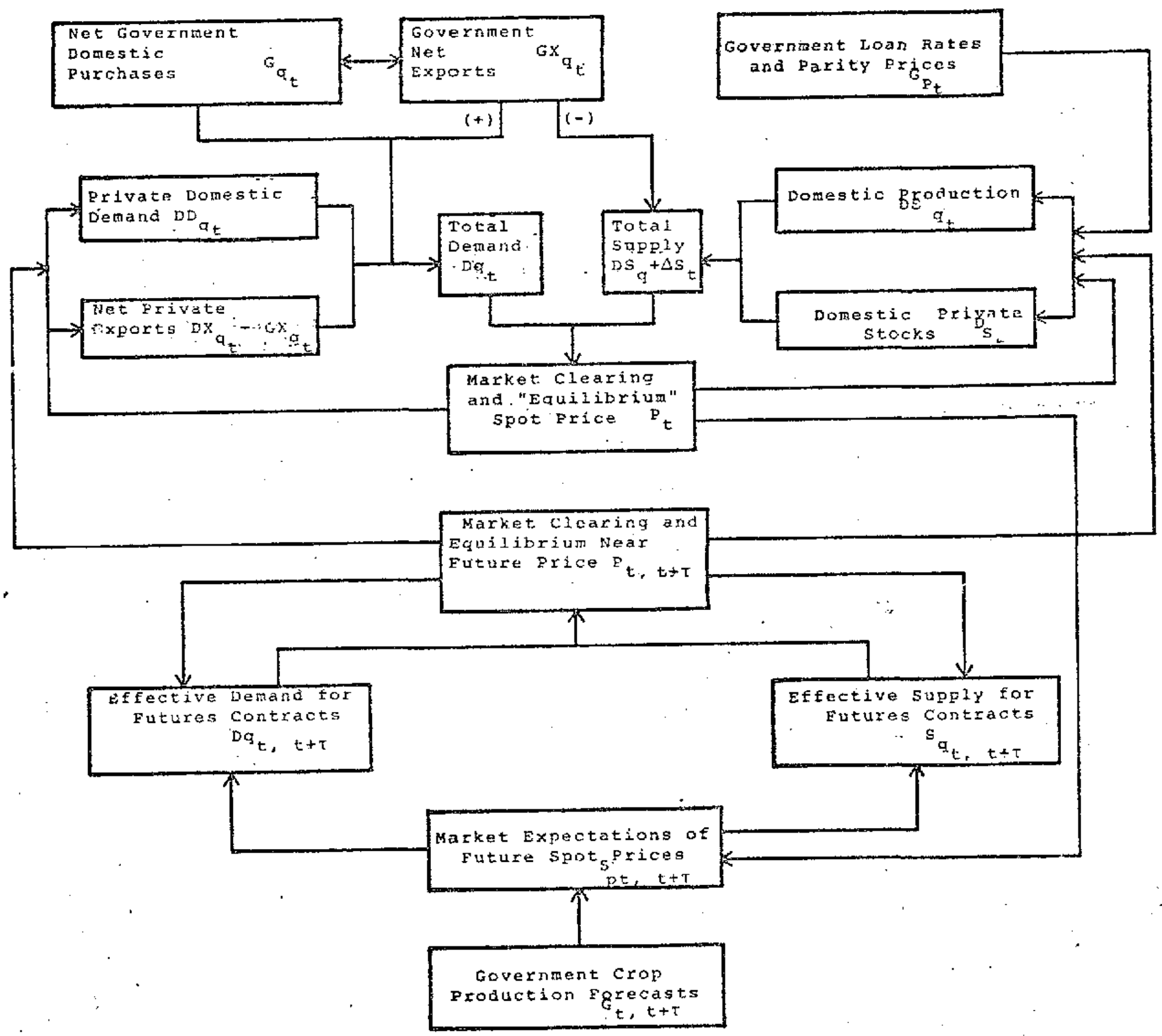


Figure II. 2 Flow Diagram of the Spot and Futures Markets Models for Agricultural Commodities

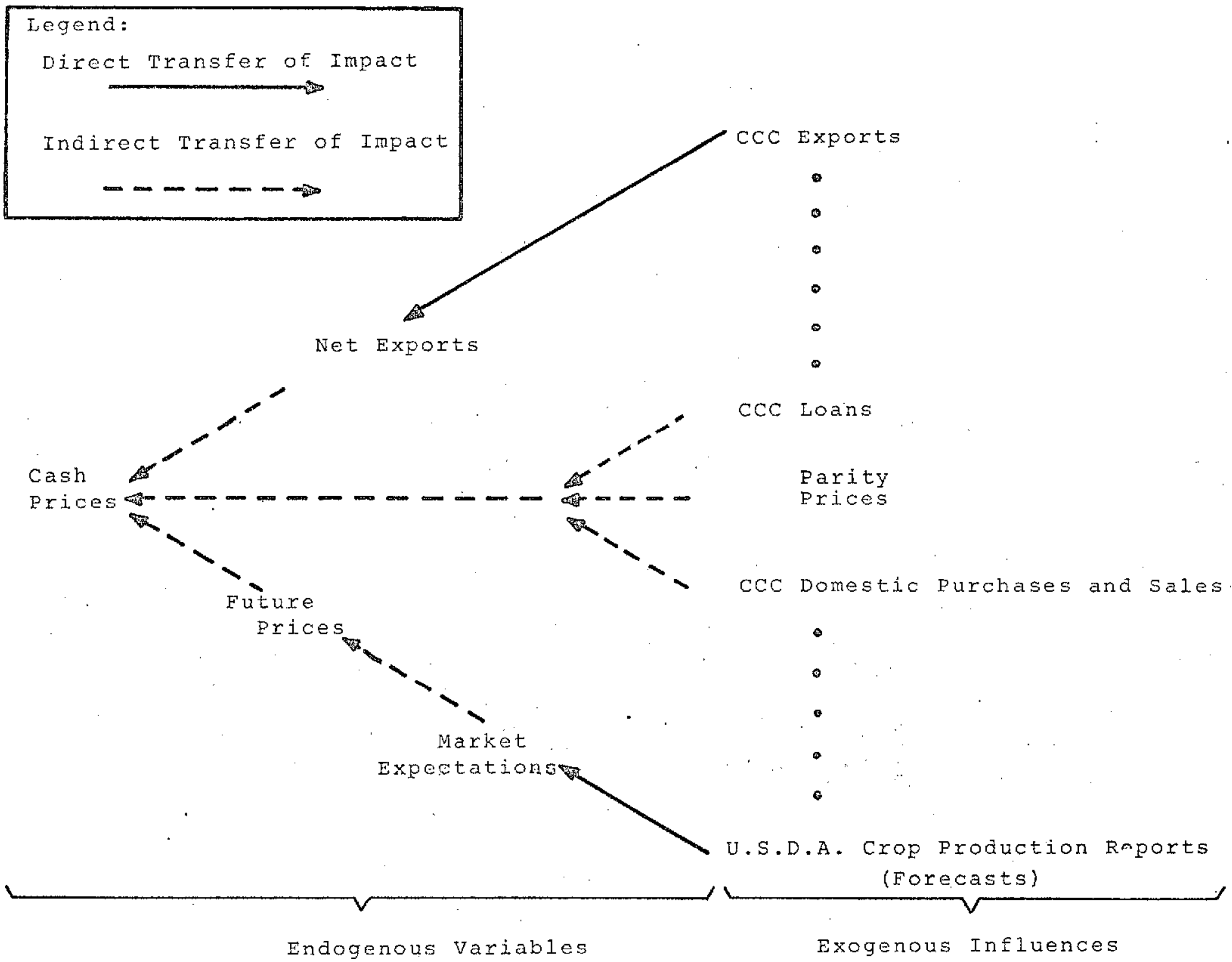


Figure II.3

Exogenous Influences on Spot and Futures Prices and sales. Crop forecasts enter the futures market directly as a driving force behind market expectations. These forecases, in turn, influence the cash market indirectly through the influence of futures prices on the spot market. The empirical objectives, of course, were to measure the timing and responsiveness of domestic prices to improvements in crop forecasts (reduced error variability), government CCC operations, and changes in the international food situation.

2. Estimation Strategy

Estimating the model presented a number of practical and methodological difficulties. The so-called practical problems centered around the data requirements. In order to distinguish between long- and short-term patterns of behavior, data with a monthly frequency were selected. However, many of the data series were inconsistent or non-existent. In the latter case, representative monthly series were constructed from quarterly data using accounting identities and/or linear prorating schemes. In the former case, the most important data construct was a futures price index. There are a number of different futures prices for a commodity, each distinguished by the contract date. However, the volume of futures contracts is reported as a total figure and is not distinguished as to these contract dates. This inconsistency, of course, makes some form of "price index" a necessity. We did not attempt to develop an optimal price index here. Instead, the generally accepted "near futures" price was employed as the representative price.

In addition to the problems of data construction, three methodological issues warrant some mention. First, the identification of, and distinction between, long- and short-run patterns of behavior. Secondly, the identification of the dynamic structures to be estimated. Finally, the interdependence of the structures and their simultaneous estimates.

a. Frequency Band Model Building: The Distinction Between the Long- and Short-Run

The model presented in the preceding section must be specified with respect to the length of the decision interval under consideration (days, weeks, etc.). Decision rules conventionally are defined relative to a specific time horizon since the causal structure of the decision process may differ with these various time perspectives. The latter assertion, of course, follows directly from the tenets of microeconomic theory where the distinction between the long- and short-run is, for the most part, the number, way, and type of variables that enter a firm's or consumer's criterion function. Dynamic considerations suggest an additional point of equal importance: a change in the decision perspective may completely alter not only the <u>nature</u>, but also the direction of causality.

Following, at least in spirit, the approach taken by Labys and Granger [49], and suggested by Granger and Hatanaka [22], each variable in the model was separated into a long-run trend/cycle component and a short-run, seasonal, and irregular component. Long-run trend/cycle and short-run seasonal and irregular models then were estimated separately. The complete time series profile of the model was obtained by combining the two distinct "frequency-band" models after their estimation.

Following generally accepted practice, moving averages (the low-pass filter) were employed to isolate the trend/cycle movements. Seasonal movements were then obtained by subtracting the trend/cycle component from the original series in each case, with the appropriate deletions made at the ends of the series. This approach, of course, bears some family resemblance to more common ratio-to-moving-average filtering techniques, such as the Census X-11 method, but does yield slightly different time series content. The results of the filters we did use were carefully checked using spectral techniques and were found to isolate the "targeted" oscillations without disturbing other oscillations or introducing spurious ones.

b. Dynamic Structures and Their Estimation

In economics, the relationship between an impulse and a response rarely is instantaneous. Instead, the response tends to build up over time. Typically, these "dynamic" relationships are explained by some combination of both lagged dependent variables and distributed lags on other explanatory variables. Often, either of these lag structures contain an infinite number of parameters. However, for practical purposes, these relationships must be replaced by "parsimonious" finite parameter approximations. In this regard, we followed the approach of Box and Jenkins [6] to identify the trend/cycle and seasonal relationships.

c. An Approach to System Estimation

As noted earlier, the model developed includes a number of jointly dependent variables in the structures. That is to say, many of the variables to be "explained" are explained in part by other variables to be explained. These interdependencies can lead to serious estimation problems if single equation estimation methods are used [58]. However, not all system estimation techniques were equally desirable. Popular estimation procedures such as two stage lease squares [58] and similar approaches require the use of so-called "reduced form" equations. For medium and larger sized models, these reduced form equations can be mammoth regressions that exceed the available degrees of freedom, i.e., there are more "things" to be explained than there are pieces of information to explain them. Moreover, even when there are sufficient degrees of freedom, these methods often require an heroic number of zero correlation assumptions [58] and/or introduce severe problems of multicollinearity: either of which can invalidate the estimation results. Because of the large number of variables in the model, it was necessary to use a method that avoids the shortcomings mentioned above, and yet provide statistically acceptable results. The method chosen here was the Fixed Point approach of Wold [58,9]. In essence, the Wold approach avoids the reduced form equations and estimates the structural parameters within the structures, using an interative least squares procedure.

3. Empirical Results

Following the estimation strategy outlined above the soybean and wheat models were estimated using monthly data. In Tables II.1 and II.2 the major impulse response elasticities in each model are summarized. The elasticities represent the net impact of a response overtime and are separated into the long-run/trend cycle and short-run/seasonal irregular impacts and all are statistically significant at the 10% level. In general the statistical results are most encouraging. The squared correlation coefficients on the trend cycle equation all exceed 90 per cent and the series of estimation residuals do not exhibit statistically significant serial correlation. For the estimating equations for the seasonal movements all have squared correlation coefficients in excess of fifty per cent and with one technical exception have serially uncorrelated residuals.

TABLE II.1 COMPENDIUM OF LONG- AND SHORT-TERM ELASTICITIES IN THE SPOT AND FUTURES MARKET FOR SOYBEANS

Response	Impulse: Net Private Exports	Private Domestic Demand	Private Stocks	Production	Short Hedging	Long Speculation	Near Futures Price	Cash Price	T-Bill Rate	Per Capita Food Prod.: Europe	Per Capita Food Production: Asia	World Price	Shipping Cost	Forecast Revision	Forecast Error Variation	Cash Price of Corn	Cash Price of Soybean Meal	Cash Price of Soybean Oil	Near Futures Price of Corn
Long Term:																			
Net Private Exports	1							-.04		-2.50	-5.01								
Private Domestic Demand		1					1.51	-.40								+.13			
Private Stocks	.72	.34	1	.93				-1.25										+.45	
Production				1			-.35	1.14								0		0	
Short Hedging			-.10		1									+.05	.04			+1.71	
Long Speculation						1			-.32					.06	.03			.63	
Near Future Price					0	0	1												
Short Term:																			
Net Private Exports	1																		
Private Domestic Demand		1																	
Private Stocks	.72	.34	1	.93				-2.30										+.60	
Production				1			0	0								0		0	
Short Hedging			-3.30		1									1.70	-.10			+1.33	
Long Speculations						1			-1.40					0	-.05			0	
Near Futures Price					-.07	+.02	1												

TABLE II.2 COMPENDIUM OF LONG- AND SHORT-TERM ELASTICITIES IN THE SPOT AND FUTURES MARKET FOR WHEAT

Response \ Impulse	Net Private Exports	Private Domestic Demand	Private Stocks	Production	Short Hedging	Long Speculation	Near Futures Price	Cash Price	T-Bill Rate	Per Capita Food Prod.: Europe	Per Capita Food Production: Asia	World Price	Shipping Cost	Forecast Revision	Forecast Error Variation	Cash Price of Corn	Cash Price of Soybean Meal	Cash Price of Soybean Oil	Near Futures Price of Corn
Long Term:																			
Net Private Exports	1							-1.57		0.72		.4							
Private Domestic Demand		1					-.24	-.56								0			0
Private Stocks	.14	.89	1	.90			-.68	.39								-.32			
Production				1			.31	.32								0			0
Short Hedging			1.93		1									0	4.37				.46
Long Speculation						1			-.73					0	0	0			0
Near Future Price					.01	1.02	1												
Short Term:																			
Net Private Exports	1																		
Private Domestic Demand		1																	
Private Stocks	.14	.89	1	.90*			-3.36	1.03								-1.56			
Production				1			.31	.32											
Short Hedging			2.85		1									0	.14	0			0
Long Speculations						1			0					0	0	0			0
Near Futures Price					-.06	+.06	1												

From the estimation results obtained, the following conclusion can be made:

- The general structure of the spot and futures markets for agricultural commodities are very similar as indicated by the elasticities presented in Tables II.1 and II.2. That is not to say that the impulse response relationships are identical but rather that the structural linkages are similar as hypothesized.
- The accuracy of crop forecasts, as measured by their error variation, exert a statistically significant influence on the futures market in both the long- and short-run.
- Hedging activity is closely related to physical stocks of agricultural commodities.
- Movements in cash or spot prices are closely related to movements in physical supplies.
- Net private exports are highly responsive to U.S. prices and per capita foreign food production.
- Domestic private demands for wheat and soybeans are responsive to the spot prices for those commodities.
- Production of soybeans and wheat is responsive to both cash and futures prices.

- Prices of commodities move directly with crop forecast accuracy. That is increases in forecast inaccuracy lead to higher commodity prices, ceterus paribus and obversely, improvements in crop forecast accuracy lead to lower commodity prices.
- A twenty five per cent improvement in the accuracy of soybean and wheat crop production forecasts, promises tens of millions of dollars worth of benefits to society.
- Improved crop production forecasts will not impinge on U.S. government domestic agricultural policy objectives and operations. In fact, improved crop forecasts will enhance the soundness of those objectives and the precision of these operations.
- Domestic production is very responsive to prices and increases in foreign demand will create upward pressures on prices.
- Foreign demand for U.S. soybean and wheat closely reflects foreign per capita food production
- Regular seasonal patterns exist in the futures markets for soybeans and wheat.
- Improved estimates of foreign food production used wisely by all trading parties can lead to "pareto optimal" exchange where neither party is worse off and at least one party is better off.

- o Failure to discriminate, or use wisely, accurate foreign crop production forecasts promises future reenactments of the "pareto suboptimal" wheat transaction between the United States and the Soviet Union.
- o Long-term credit availability is an important influence in the commodities markets and is influenced by inflation and the factors influencing the rate of inflation.

B. Policy Conclusions

In addition to the specific conclusions presented above there are at least two important policy conclusions that warrant special mention: these topics are the value of ERTS improved crop forecast accuracy and the impact of ERTS forecasts on U.S. government agricultural policy operations and planning. Each of these are summarized in the following paragraphs.

1. The Value of ERTS Improved Crop Forecast Accuracy.

In Chart II.4 the improvement of ERTS crop forecast accuracy over current systems is illustrated. Conservative estimates place the ERTS improvement at 25 per cent over current projections. Using this assumption benefits estimates were calucated using the elasticities in Tables 11.1 and II.2 together with 1973 prices and quantities as illustrate in Figure II.4. The calculation of these benefits are illustrated in Figure II.5.

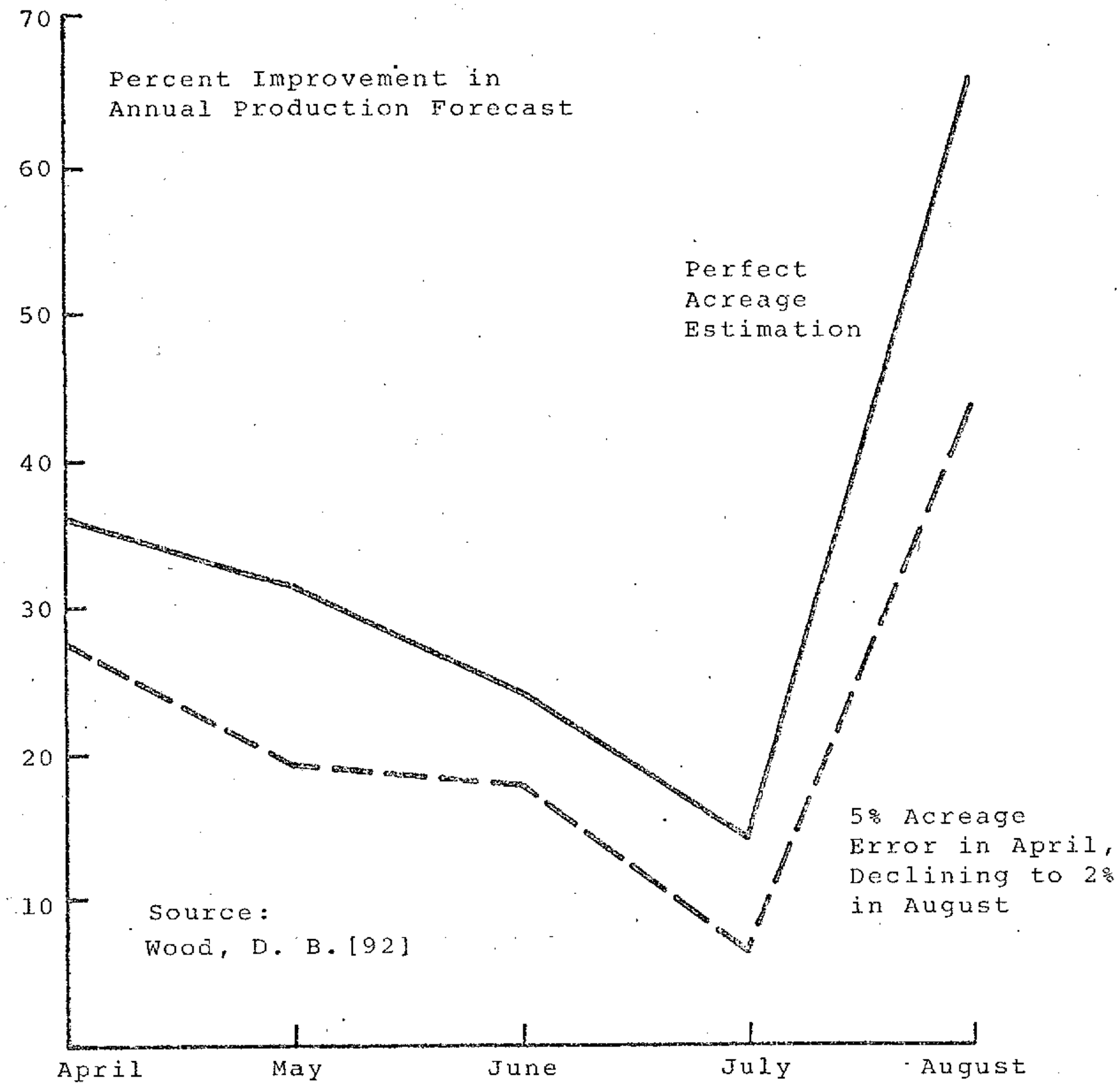


Chart II.4 Illustrative ERTS Accuracy Improvement

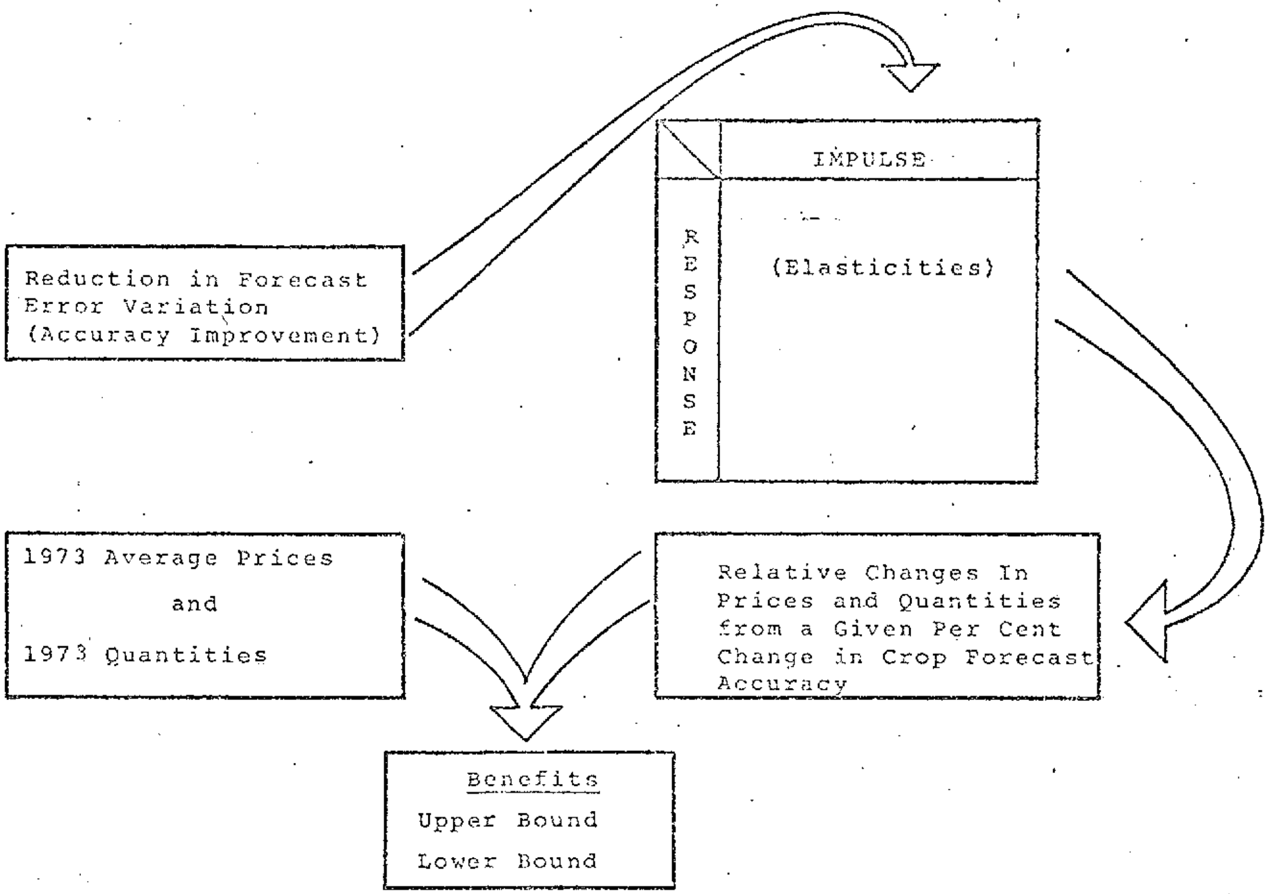


Figure II.5 The Calculation of Benefits

The estimated benefits measure in the tens of millions of dollars for both soybeans and wheat and are presented in Table II.3. The upper bound estimates correspond to the direct consumer benefits using the estimated elasticities. The lower bound benefits are the direct benefits to the consumer using the elasticities based on estimation coefficients two standard locations away from the estimated value. Although the lower bound benefits values are not large they are substantial.

2. Crop Projections and Coordinated Policy Actions

A common domestic objective of the government, operating through the CCC, is to ensure a parity price for certain agricultural commodities such as wheat. The basic operating rule for the CCC is to purchase a commodity when the market price threntens to fall below parity and sell the commodity when prices have surged beyond some predetermined upper limit. These actions.

Table II.3 Estimates of Annual ERTS Benefits (Based on Likely Reduction in Crop Production Forecast Error Variation as Determined by D.B. Wood [92].

	Annual Benefits	
Crop	Lower Bound	Upper Bound
Soybeans	$ 71 mill	$337 mill
Wheat	35 mill	212 mill
TOTAL	$106 mill	$549 mill

by the government serve to increase demand in the former case and increase supply in the latter. Ceterus paribus, the results in turn exert upward or downward pressures on prices, respectively.

Market prices, however, also reflect exprected demands and expected supplies. Because crop forecasts, and therefore expected supplies, change from month to month as the harvest draws near the government nay be buying one month and selling the next in response to changes in market expectations owning to changes in crop forecasts.

To the extent that forecast errors manifest themselves in suprious price movenments, the government will buy and sell the affected commodity to keep its price within bounds. Thus the government act to insulate the market from forecast "noise". Obersely if the forecasts were perfect the fovernment still may enter the market to offset any demand-supply inbalance vis a vis desired prices. ERTS information of course will not alter these operating rules. The impact of ERTS in the context simply will be to reduce the "noise" the government must filter from the system. Thus, ERTS improved forecasts may exert a passive influence on government domestic operations. However, there is one way in which the ERTS noise reduction may enhance government policy operations. Every reduction in market noise only improves the government's view of the market and therefore helps the government design and implement better and more efficient agricultural policies.

The most recent Russian wheat deal illustrates the importance of a world wide monitoring system and how such a system can assist U.S. agriculture export policies. In early to mid 1973 the United States opened its wheat supplies to the Soviet Union. At this time it was known that the Soviets would experience a serious short fall in wheat production. However, the size of the short fall and the potential purchase was not known to the market. Recognizing the economic value of an uninformed well intentioned trading partner, the Russians moved swiftly and purchased millions of tons of wheat for future delivery at prices that reflected the market's ignorance. Soon after the massive Russian entry into the market U.S. domestic prices soared to record levels.

In its negotiating with the Soviet Union the United States government expected Soviet purchases of up to 10 million tons. The elasticities presented in Table II.2, and based on 1960-1971 data, suggest that such a massive increase in demand would raise prices by almost 100 per cent. In fact the Soviets contracted for 10 million tons of wheat in less than a month and went on to purchase at least an additional 2 million tons. Had this market impact been known by the United States the Russian entry into the market could have been phased over a longer period. In this way the market could have adapted to each Soviet bid and, as prices rose, the Soviet appetite may have been curbed. At the least, the Soviets would have shared the first operational costs of detente.

On the one hand the new round of inflationary pressures brought on by the Russian wheat deal, could have been reduced through the intelligent scheduling of the Soviet entry into the market by the U.S. trade negotiators. On the other hand, even if the U.S. trade negotiators were not wise to the likely market impact of such a transaction the market was. The problem here, of course, is that the U.S. trade negotiators and the market did not have accurate estimates of Russian demand i.e., we did not have accurate estimates of the short fall in the Russian harvests. Had this information been available to the market, and the U.S. trade negotiators, the market could have taken a realistic bargaining position. It is clear that ERTS type information, together with knowledge of the market and intelligent bargaining could have satisfied Russian demands without full subsidization by the American consumer.

C. Recommendations for Further Research

The operating thesis of this study was to focus on major issues and robust findings; leaving important but secondary issues for future research. Among the most important of these issues and problems are the following:

- Owing to the interdependencies between crop production decisions and between crop consumption decisions a full complement of agriculture of commodities should be studied in detail.

- Because individual crops vary in quality, harvest time and final use, considerable attention should be directed toward these intensive issues to better understand the incidence of societal benefits from ERTS for each crop.
- Differences in tastes, soil fertility and harvest time all suggest that foreign demand for U.S. agricultural commodities be investigated with much greater detail so as to assess properly the benefits of ERTS to all trading partners.
- Further work must be done to improve the quality of the current data used for empirical estimation. Here improved sampling procedures and more complete and highly resolved records are most important.
- The channels of communication that transmit production forecast data to the market should be studied in detail so as to properly assess the value of timeliness in crop forecast information.

- The competitiveness of the domestic markets for agricultural commodities should be studied in order to identify possible information bottlenecks.

Each of these issues is a major topic in itself and their absence from this study only serves to dilute its potential. Nevertheless, the findings are substantial and argue strongly for the implementation of an ERTS system. To be sure, the substantial benefits from ERTS may not be realized owing to the unscrupulous acts of those who would restrain trade for private gain or because the information from ERTS is not used or disseminated wisely. Ignorance and wanton abuse, of course, are not reasons to refrain from implementing an otherwise beneficial system.

III. THE COMMODITIES MARKETS: A FRAMEWORK FOR ANALYSIS

In the following paragraphs, we present a general model of the domestic spot and futures markets for agricultural commodities. Our objective here is to develop a practical understanding of these markets, with special emphasis on the impacts of information improvement and net exports, in order to provide a systematic framework for empirical measurement and policy analysis. The section is presented in three parts. First, we present the structures describing the spot market. Next, we summarize the structure of the futures market. Finally, we discuss the linkages between the two models and join them into a simultaneous system.

Before turning to the structures of the spot and futures markets and their interaction, we first set forth the heritage of the present modeling effort. This heritage has three major dimensions: the basic market influences and their avenue of introduction, the principal behavioral hypotheses postulated, and the distinction between long- and short-run decision intervals.

With respect to the first "dimension", the basic market influences may be divided into four distinct categories: those acting through demand in the spot and futures markets, those acting through supply in those markets, those acting through macro economic conditions, and those acting through the structure of the spot and futures markets. Table III.1 summarizes the major factors that have been associated with each of these categories. The structural location and role of these factors are specified in the models to be presented.

The impact and interpretation of the measurable influences listed in Table III.1 depend, in part, upon the behavioral concepts that transform them into a "positive" or descriptive model of economic behavior in the spot and futures markets. The major hypotheses drawn upon in this study are presented in Table III.2. That is not to say that the present effort has attempted to test each of these hypotheses individually. Rather, that these notions are not mutually exclusive, each contributes to the structural character of the model, and that any reasonable model should be general enough to accommodate these elements.

Finally, the architectural design of the model has been fashioned, in part, from earlier empirical results [49]. Foremost among these guidelines are the modeling rules listed in Table III.3. Here, the most promising methodological approaches are categorized according to the length of the decision interval. In all, four decision intervals are presented: days, weeks, months, and quarter years or longer. It must be noted that we have not attempted to construct a different model corresponding to each of the four decision intervals presented in Table III.3. However, using monthly data, we do make an

Table III.1 Compendium of Market Influences*

1. Acting Through Demand

   a. Domestic consumption
   b. Exports
   c. Derived demand for final products
   d. Government stockpiling and aid programs
   e. Demand relatives such as the prices of substitutable commodities or substitutes resulting from innovation

2. Acting Through Supply

   a. Production
   b. Stocks
   c. Weather
   d. Government subsidy and crop-control programs
   e. Supply relatives such as the production of substitutable commodities or innovation induced increases in production

3. Acting Through Economic Conditions

   a. Business conditions as reflected in industrial production, unemployment, and the general price level
   b. Credit conditions which define the availability of loans for speculation or commodity storage

4. Acting Through Market Composition

   a. Speculating
   b. Hedging

*Source: Labys, W. and Granger, C. W. J., Speculation, Hedging and Commodity Price Forecasts, Heath Lexington, Lexington, Mass. 1970.

Table III.2 Compendium of Analytical Concepts*

Specific Concepts	General Concepts
1. Open-Contract Concept: Futures markets serve primarily to facilitate contract holding.	1. Portfolio Section: "Investment" decisions are based in part on both return and risk considerations.
2. Hedging-Market Concept: Futures markets depend for their existence primarily on hedging.	2. Expectations: Intertemporal decisions are based in part on expected economic phenomena.
3. Multipurpose Concept of Hedging: Hedging is done for a variety of different purposes and must be defined as the use of futures contracts as a temporary substitute for a merchandising contract, without specifying the purpose.	3. The Rate of Change in Prices: Prices change in proportion to the imbalance between supply and demand.
4. Price-of-Storage Concept: Storage of a commodity is a service supplied often at a price that is reflected in intertemporal price spreads.	4. The Length of The Decision Interval: The causal structures of long-run patterns of behavior are distinct from their short-run counterparts.
5. Concept of Reliably Anticipatory Prices: Futures prices on average tend to be highly reliable estimates of what should be expected on the basis of contemporarily available information concerning present and future demand and supply, but may reflect these expectations at each point in time owing to technical rigidities in the markets' response to changes in information on supply and demand prospects.	5. Future values are discounted back to the present.
6. Market-Balance Concept: Changes in futures prices are attributed, in part, to a lack of balance between short hedging and long speculation.	

*Adapted in part from Holbrook Working, "New Concepts Concerning Futures Markets and Prices", American Economic Review, 52(June 1962).

Table III.3 Decision Interval and Modeling Approach

Decision Interval	Approach
Days (Intra Monthly Frequency)	Random Walk*
Weeks (Entra Monthly Frequency)	Random Walk*
Months (Intra Quarter and Annual Frequencies)	Systematic and Seasonal Behavioral Components together with a Random Component*
Quarters or Longer (Semi-Annual or Longer Frequencies)	Trend/Cycle and Seasonal Behavioral Relationships plus a Random Component**

*Source: Labys, W.C. and Granger, C. W. J., Speculation, Hedging and Commodity Price Forecasts, Heath Lexington Books, Lexington, Mass. 1970, p.205-216.

**See for example, Houck, J. P., Ryan, M. E., Subotnik, A., Soybeans and Their Products: Markets, Models, and Policy, University of Minnesota Press, Minneapolis, 1972. Chapters 5 and 6.

effort to distinguish between long-run trend/cycle and short-run seasonal and irregular patterns of behavior in keeping with the guidelines presented in Table III.3.

With these influences, hypotheses, and decision intervals defining the bounds and directions of our investigation, we now are ready to set forth our structures of the spot and futures markets.

A. The Spot Market

The analytical foundation of our model of the spot market is presented in four parts. The first segment describes the demand side of the model. The second part summarizes the supply side. The third segment lists the necessary market clearing equations and other constraints. Finally, the entire spot market model is summarized.

1. The Demand Block

Following the tenets of static economic theory, the domestic private demand for a good or service at any point in time will be a function, in part, of its own price, the prices of substitutes and complements and selected other variables that typically define some constraint(s) on that demand.[1] Denoting these prices $P^{(i)}$, $i=1,\ldots,I$ and the other variables

1. Government demand is considered in the market clearing equations.

$X^{(v)}$, $v=1,\ldots,V$, the demand relationship for commodity (j) in the spot market at time t, ${}^{DD}q_t^{(j)}$ can be written,

$$ {}^{DD}q_t^{(j)} = D_1\left(P_t^1,\ldots,P_t^I,X_t^1,\ldots,X_t^V\right) + U_{1t}, \tag{1} $$

where U_{1t} is a random "residual".[2]

Insofar as a future commodity τ time periods in the future may be viewed as a substitute or complement for the same or another commodity today and dealers in the spot market may elect to go into the futures market, a realistic modification of Equation (1) would be to include the discounted prices of all relevant commodities at that future time, $\overline{P}_{t,t+\tau}$, assuming those prices were known. With these modifications, the typical intertemporal demand equation would be of the form,

$$ \begin{aligned} {}^{DD}q_t^{(j)} = D_2\Big(&P_t^1,\ldots,P_t^I,\overline{P}^1_{t,t+\tau},\ldots,\overline{P}^I_{t,t+\tau}, \\ &X_t^1,\ldots,X_t^V\Big) + U_{2t}, \end{aligned} \tag{2a} $$

where U_{2t} is a random residual,

$$ \overline{P}^{(i)}_{t,t+\tau} = P^{(i)}_{t,t+\tau}(1+r)^{-\tau}, \tag{2b} $$

and r is the rate of discount.

2. See comment six in Section I, page I-6.

Private and government (CCC) exports and imports for a commodity can be accommodated by a single relationship. Here, CCC net exports are treated as exogenous to the model and a positive quantity denotes an export and a negative quantity denotes an import. Owing to the wider range of markets, private net export demand for a commodity will depend not only upon the variables included in Equation (2), but also on competing world market prices, transport costs, purchasing power, and tariffs, among other factors. Using vector notation, a typical total "export demand" equation may be written,

$$^{DX}q_t^{(j)} = D_3\left(P_t, \bar{P}_{t+\tau}, \bar{P}_t^W, \bar{P}_{t+\tau}^W, Y_t\right) + {}^{GX}q_t^{(j)}, + U_{3t}, \qquad (3)$$

where $^{GX}q_t^{(j)}$ is net CCC exports, P_t and $\bar{P}_{t+\tau}$ are vectors of current and discounted futures commodity prices in the United States market respectively, P_t^W and $\bar{P}_{t,t+\tau}^W$ are vectors of current and discounted futures "world" commodity prices adjusted for net tariffs and transport costs, Y_t is a vector of other influential factors such as foreign per capita income and past per capita foreign commodity supplies, and U_{3t} is a random element.

Before turning to the stock adjustment mechanism, some further comment on $\bar{P}_{t+\tau}^W$ is warranted. The "true" world price that competes with our domestic price for a commodity can be better approximated by adding to it the average net increment in costs owing to lower (higher) U.S. tariffs relative to the rest of the world and a similar term for transport cost differences. For our purposes, these unit cost adjustments will be approximated by,

$$TF^{(j)} = (\text{Average U.S. tariff cost per unit} - \text{Average rest of world tariff cost, per unit}), \tag{4}$$

and

$$TR^{(j)} = (\text{Average shipping cost from U.S. per unit} - \text{Average rest of world shipping cost per unit}), \tag{5}$$

depending, of course, on market origin and destination.

The expected value of these costs at time $(t+\tau)$ are assumed to be the same as their value at time t, i.e., a "no change" hypothesis, owing to the imperfections in the disseminations of information on a world-wide basis.

Combining these considerations, the spot and discounted futures world prices for a commodity would be,

$$\bar{P}^W_t = \left[P^w_t + TF_t + TR_t\right] \tag{6a}$$

and

$$\bar{P}^W_{t+\tau} = \left[P^w_{t+\tau} + TF_t + TR_t\right] (1+r)^{-\tau} \tag{6b}$$

respectively, where $P^w_{t+\tau}$ denotes the undiscounted world futures price unadjusted for TF and TR. The empirical specification of the indexes TF and TR are presented in Section IV.

The domestic stock of a commodity introduces dynamics in- into our model in the classical Nerlove tradition [60,61]. The desired domestic private stock of commodity (j), ${}^{D}S_t^{*(j)}$ is assumed to be a function of the actual stocks of other commodities $S_t^{(i)}, i-1,\ldots,I, i\neq j$, the current price of commodities in the U.S. commodities market, P_t, and discounted futures prices, $\overline{P}_{t,t+\tau}$, adjusted for marginal storage costs, C. This function can be expressed,

$$ {}^{D}S_t^{*(j)} = S_1\left(S_t^1,\ldots,S_t^I,P_t,\overline{P}_{t,t+\tau}\right) + U_{7t} \tag{7}$$

where

$$\overline{P}_{t,t+\tau} = \frac{(1-\delta)^\tau}{(1+r)^\tau} P_{t,t+\tau} - C\tau, \tag{8}$$

δ is the decay rate, $P_{t,t+\tau}$ is the unadjusted futures price and U_{7t} is a random.

Following Nerlove, the relation between actual and desired levels of domestic private stocks is assumed to follow an adjustment process of the form,

$$\Delta^D S_t^{(j)} = \gamma^{(j)}\left({}^{D}S_t^{*(j)} - {}^{D}S_{t-1}^{(j)}\right) + U_{9t}, \tag{9}$$

where $\Delta^D S_t^{(j)} = {}^{D}S_t^{(j)} - {}^{D}S_{t-1}^{(j)}$, and U_{9t} is a random disturbance.

Combining (7), (8), and (9), the typical stock <u>level</u> equation would be,

$$ {}^{D}S_t^{(j)} = \gamma^{(j)} S_1\left(S_t^1,\ldots,S_t^I,P_t,\overline{P}_{t,t+\tau}\right) + \left(1-\gamma^{(j)}\right){}^{D}S_{t-1}^{(j)} + U_{10,t} \tag{10a}$$

where $U_{10,t} = U_{9t}$.

It must be noted that storage capacity and its long-term dynamics are included implicitly in (9). Although short-term capacity shortages can have serious impacts on prices, these problems lose much operational significance in the context of government stockpile (and export) operations designed to maintain agricultural price stability. To be sure, domestic storage capacity then becomes an important determinate of government operations. However, these government decisions are entertained outside of the empirical model and are discussed in our policy analysis.

It also should be noted that the total stock of a commodity, $S_t^{(j)}$, consists of the sum of private stocks ${}^{D}S_t^{(j)}$ plus government stocks ${}^{G}S_t^{(j)}$. That is,

$$S_t^{(j)} \equiv {}^{D}S_t^{(j)} + {}^{G}S_t^{(j)}, \tag{10b}$$

where ${}^{G}S_t^{(j)}$ is exogenous to this model.

Finally, total demand is given by the identity,

$${}^{D}q_t^{(j)} \equiv {}^{DD}q_t^{(j)} + {}^{DX}q_t^{(j)} + {}^{G}q_t^{(j)}. \tag{10c}$$

2. The Supply Block

In this subsection, we outline the basic relationships describing the production of agricultural commodities in the U.S. The supply from foreign sources already has been considered in the next export demand Equation (3) and will not be repeated here. Following standard practice, domestic production ${}^{SD}q_t^{(j)}$ is decomposed into harvested acreage $A_t^{(j)}$ times yield $Y_t^{(j)}$ and separate relationships are developed for each.

In general, the production of commodity (j) at time t, ${}^{DS}q_t^{(j)}$, is assumed to be a function of the price of commodity (j), the prices of substitutes and complements for that commodity, and the prices of factors of production, such as fertilizer, etc. However, three such sets of these prices must be considered: lagged, expected, and actual prices. Lagged and expected prices must be considered so as to capture the influence of past returns and expectations on potential production, respectively. Current prices must be considered so as to capture the "harvest" decision which may lead to the harvesting of some fraction of the "potential" harvest acreage and, therefore, result in actual production being some fraction of potential production. The first two sets of prices together are assumed to determine the <u>desired</u> harvest acreage and yield for commodity (j):

$$A_t^{*(j)} = \mathcal{H}\left(\overline{P}_{t-\tau,t}, P_{t-\tau,t-\tau}\right), \tag{11}$$

and

$$Y_t^{*(j)} = \mathcal{G}\left(\overline{P}_{t-\tau,t}, P_{t-\tau,t-\tau}\right), \tag{12}$$

where $\overline{P}_{t-\tau,t}$ is a vector of discounted commodity and factor prices expected at time $t-\tau$ for time t, and $P_{t-\tau,t-\tau}$ is a factor of lagged actual prices. (11) and (12) represent the farmer's expected profit maximizing decisions as of time $t-\tau$ for time t.

Following Nerlove, [62, 64, 65], the actual or observed change in harvested acreage at time t is assumed to be a linear function of the desired change in harvested acreage (a measure of the potential speed with which this adjustment may take place) and current actual prices. That is,

$$\Delta A_t^{(j)} = \gamma_2^{(j)}\left(A_t^{*(j)} - A_{t-1}^{(j)}\right) + f_3\left(P_t\right) + U_{13,t}, \tag{13}$$

where $\Delta A_t^{(j)} = A_t^{(j)} - A_{t-1}^{(j)}$ and $U_{13,t}$ is a random element.

Combining (11), (12), and (13), the actual production of commodity (j) at time t would be written,

$$\begin{aligned} {}^{DS}q_t^{(j)} = {} & \left[\gamma_2^{(j)} \mathcal{H}\left(\left(\bar{P}_{t-\tau,t}, P_{t-\tau,t-\tau}\right) + f_3\left(P_t\right) + \left(1-\gamma_2^{(j)}\right)\right.\right. \\ & \left. A_{t-1}^{(j)} + U_{13,t}\right] \left[\mathcal{F}\left(P_{t-\tau,t}, P_{t-\tau,t-\tau}\right) + U_{14,t}\right], \end{aligned} \tag{14}$$

where $U_{14,t}$ is a random element distinguishing actual from desired yield.

3. Market Clearing Equations, Constraints, and Expectations

Before summarizing the model for the spot market, some loose ends first must be tied: the equilibration of supply with demand, accounting for selected market constraints, and the specification of expected prices in the spot market.

Without the existence of government stockpile/price support policies, the equilibration of demand and supply in our model would be denoted simply,

$$DS_{q_t}^{(j)} - DD_{q_t}^{(j)} - DX_{q_t}^{(j)} = \Delta S_t^{(j)}. \tag{15}$$

That is to say, production plus changes in stocks equal total demand.

However, the government often adds to, or reduces, its stock of a commodity in order to support some predetermined target price or for some other political reason. In this model, net domestic government demand, ${}^{G}q_t^{(j)} \equiv \Delta^G S_t^{(j)}$, will be considered, but treated as exogenous to the mainstream of the model, i.e., determined outside the model. Including domestic government demand, the typical market clearing equation is written,

$$DS_{q_t}^{(j)} - DD_{q_t}^{(j)} - DX_{q_t}^{(j)} - {}^{G}q_t^{(j)} = \Delta S_t^{(j)} \tag{16}$$

where, of course, $\Delta S_t^{(j)} = \Delta^D S_t^{(j)} + \Delta^G S_t^{(j)}$.

It is worth noting at this time that, owing to the market clearing equation, the equilibrium price and quantity of a commodity will be determined, in part, by U.S. Government commodity purchases or sales. This result follows from the seeming redundancy between Equation (16) and Equations (10a) and (10b). Equation (16) implies the change in total domestic stocks. Similarly, Equations (10a) and (10b) also may be used to solve for the change in total domestic stocks given $\Delta^G S_t^{(j)}$ which is taken to be exogenous. However, following common practice, Equation (16) will be "inverted" and used to estimate the equilibrium price in the spot market.[2] Naturally, this transformation introduces another random element, $U_{16,t}$.

In addition to the market clearing equations, four other constraints also must be stated. These constraints are straightforward and are presented here with little further comment.

Net Export Restrictions $\quad {}^{DX}q_t^{(j)} \leq E_t^{(j)}$, (17)

where $E_t^{(j)}$ is exogenous.

Non-Negativity $\quad {}^{DD}q_t^{(j)},\ {}^{DS}q_t^{(j)} \geq 0$, (18)

$$P_t,\ P_{t,t+\tau} \geq 0, \tag{19}$$

$$S_t^{(j)} \geq 0. \tag{20}$$

---

[2] A similar procedure is employed in many large-scale financial models. Most of these models over-determine the reserve identity equating the sources and uses of bank reserves. More often than not, structural equations are specified for excess reserves, borrowed reserves and currency, identities are employed for required reserves and non-borrowed reserves, and non-borrowed reserves then is treated as exogenous. These assumptions initially produce a system of five equations in four unknowns. This potential impass usually is avoided by rearranging either one of the estimated structural equations or a reserve identity in order to derive an entirely new endogenous variable and thus create a new subsystem of five equations in five unknowns.

$$\text{Profit Maximization} \quad \frac{(1-\delta)^{\tau}}{(1+r)^{\tau}} P_{t,t+\tau} - C\tau \geq P_t. \tag{21}$$

The profit maximizing condition, (21), simply states that owners of stocks will hold their stocks to time $t+\tau$ and not sell them in time t only if the discounted "effective" futures price is no less than the current spot price. The effective futures price is the raw futures price $P_{t,t+\tau}$ adjusted for the decay in storage $(1-\delta)$ where δ is the decay rate, less the incremental storage costs $C\tau$. [3,7,46,76,94,95].

Throughout the spot market model, price expectations play an important role. To be sure, the last word on expectations has not been written and, at best, one can only approximate this complex process. The approach taken here is to use domestic futures prices as the prevailing domestic price expectation influencing the domestic spot market. The actual expectations mechanism and the determination of the futures price is deferred to the section describing the model of the futures market. Although this approach has a number of shortcomings, not the least of which are the estimation problems owing to the simultaneity between the spot and futures markets, it is felt that this "stagging" of the model is necessary for its analytical tractability. Finally, it should be noted that actual world prices will be used as a surrogate for expected world price and that these prices are exogenous to the model.

4. Summary

In Tables III.4 and III.5, we summarize the general structure of the spot market model and the associated mnemonics, respectively.

TABLE III.4 STRUCTURE OF THE "SPOT" MARKET

Equations		
Private Domestic Demand	$DD_{q_t}^{(j)} = D_2(P_t, \bar{P}_{t,t+\tau}, X_t) + U_{2t}$	(2a)
Net Export Demand	$DX_{q_t}^{(j)} = D_3(P_t, \bar{P}_{t,t+\tau}, P_t^W, P_{t+\tau}^W, Y_t) + GX_{q_t}^{(j)} + U_{3t}$	(3)
Domestic Private Stocks	$D_{S_t}^{(j)} = \gamma_1^{(j)} S_1(S_t, P_t, \bar{P}_{t,t+\tau}, C) + (1-\gamma_1^{(j)})\, {}^{D}S_{t-1}^{(j)} + U_{10,t}$	(10)
Domestic	$DS_{q_t}^{(j)} = \left[\gamma_2^{(j)} (\bar{P}_{t-\tau,t}, P_{t-\tau,t-\tau}) + f_3(P_t) + (1-\gamma_2^{(j)})\, \lambda_{t-1}^{(j)} + U_{13,t}\right] Y_t^{(j)}$	(14)
Identities		
Total Demand	$D_{q_t}^{(j)} = DD_{q_t}^{(j)} + DX_{q_t}^{(j)} + G_{q_t}^{(j)}$	(10c)
Market Clearing	$DS_{q_t}^{(j)} - D_{q_t}^{(j)} = \Delta S_t^{(j)}$	(16)
Total Domestic Stock	$S_t^{(j)} = D_{S_t}^{(j)} + G_{S_t}^{(j)}$	(10b)
Discounted Domestic Prices	$\bar{P}_{t,t+\tau}^{(j)} \equiv P_{t,t+\tau}^{(j)} (1+r)^{-\tau}$	(2b)
Discounted Adjusted World Prices	$\bar{P}_{t,t+\tau}^{(j)} \equiv \left[P_{t,t+\tau}^{w(j)} + TF_{t,t+\tau}^{(j)} + TR_{t,t+\tau}^{(j)}\right] (1+r)^{-\tau}$	(6)
Net Tariff Advantage	$TF_f^{(j)} \equiv$ (Average U.S. Tariff$^{(j)}$ − Average rate of world tariff$^{(j)}$)	(4)
Net Transport Cost Advantage	$TR_t^{(j)} \equiv$ (Average U.S. Transport Cost$^{(j)}$ − Average rate of world transport cost$^{(j)}$)	(5)
Discounted Effective Storage Price	$\bar{P}_{t,t+\tau} \equiv \frac{(1-\delta)^{\tau}}{(1+r)^{\tau}} P_{t,t+\tau} - C\tau$	(8)
Inequality Constraints		
Net Export Constraints	$DX_{q_t}^{(j)} \begin{cases} \leq E_{1\,t}^{(j)} & (+) \\ \leq E_{2\,t}^{(j)} & (-) \end{cases}$	(17)
Non-Negativity	$DD_{q_t}^{(j)},\ DS_{q_t}^{(j)} \geq 0$	(18)
	$P_t,\ P_{t,t+\tau} \geq 0$	(19)
	$S_t^{(j)} \geq 0$	(20)
Profit Maximization	$\frac{(1-\delta)^{\tau}}{(1+r)^{\tau}} P_{t,t+\tau} - C\tau > P_t$	(21)

TABLE III.5 MNEMONICS FOR TABLE III.4

${}^{DD}q_t^{(j)}$	=	Private domestic demand for commodity (j) at time t.
${}^{DX}q_t^{(j)}$	=	Net export demand for commodity (j) at time t.
${}^{DS}q_t^{(j)}$	=	Domestic production of commodity (j) at time t.
${}^{G}q_t^{(j)}$	=	Government domestic purchases or sales of commodity (j) at time t.
${}^{GX}q_t^{(j)}$	=	Net C.C.C. exports of commodity (j) at time t.
$S_t^{(j)}$	=	Domestic stock of commodity (j) at time t.
$P_t^{(j)}$	=	Domestic spot price of commodity (j) at time t.
$P_{t,t+\tau}^{(j)}$	=	Domestic futures price of commodity (j) for time t+τ at time t.
$P_{t,t+\tau}^{W,(j)}$	=	World price of commodity (j) for time t+τ at time t.
X_t, Y_t	=	Vector of exogenous variables.
$C^{(j)}$	=	Marginal storage cost of commodity (j).
$A_t^{(j)}$	=	Harvested acreage of commodity (j) at time t.
r	=	The rate of discount.
$E_{1t}^{(j)}, E_{2t}^{(j)}$	=	The export and import constraints on commodity (j) at time t, respectively.
$y_t^{(j)}$	=	The yield per acre for commodity (j) at time t.
$\delta^{(j)}$	=	The rate of decay for commodity (j).

B. The Futures Market

In the following paragraphs, the structural relationships describing our model of the futures market are presented. We first present the demand side of the market. The supply side and price adjustment mechanisms are presented next. The third topic presented is expectations. Operational constraints then are listed. Finally, the complete futures model is summarized in Tables III.6 and III.7. As for the model of the Spot Market, the relationships presented here are aggregate and not product specific.

1. The Demand Block

The "effective" demand for forward sales contracts is assumed to come from speculators, who hope to gain from "backwardation" - the difference between discounted expected spot and future prices [21, 28, 37, 39, 70].[4] In addition, "portfolio" and financial considerations strongly suggest that speculators also may be sensitive to the "variability risk" surrounding their expected gain from backwardation and the cost of money associated with their purchases. [21,28,78,79]

The "portfolio selection" character of the demand relationship follows directly from our general view of speculators. In essence, they are assumed to be investors that seek to either maximize their expected return from their investment in commodi-

---

4. The notion of "effective" demand is patterned after Hicks [27] and is described in Section III B.3.

ties, subject to risk constraints, or they seek to minimize their risk subject to some earnings requirement.

With these points in mind, the demand for forward sales contracts can be written

$$D_{q_{t,t+\tau}}^{(j)} = D_4^{(j)} \left[({}^S\bar{P}_{t,t+\tau} - \bar{P}_{t,t+\tau}),\ \sigma_{{}^S\bar{P},\bar{P},r'} \right] + U_{22,t} \quad (22)$$

where ${}^S\bar{P}_{t,t+\tau}$ is a vector of discounted expected spot prices, $\bar{P}_{t,t+\tau}$ is a vector of discounted future prices, r' is the cost of money [74], $\sigma_{{}^SP,P}$ denotes the variation in the backwardation component $({}^S\bar{P}_{t,t+\tau} - \bar{P}_{t,t+\tau})$ and is assumed to capture the risk associated with the expected gains from backwardation and $U_{22,t}$ is a random element.

2. The Supply Block

The "effective" supply of forward sales contracts is assumed to come primarily from owners of physical stock demanding hedges.[5] As in the demand block, the attractiveness of a hedge is assumed to be dependent upon backwardation and its variation. Unlike the demand block, however, total available domestic stocks of commodities, S_t, also are assumed to play an influential role [27].

Algebraically, this supply function can be

5. The notion of "effective" supply used here, also is Hicksian in origin, [27] and is described in Section III B.3.

written

$$S_{q_{t,t-\tau}}^{(j)} = S_2^{(j)} \left[(S_{P_{t,t+\tau}} - \overline{P}_{t,t+\tau}),\ \sigma_{S_{\overline{P},\overline{P},S_t}} \right] + U_{23,t} \qquad (23)$$

where $u_{23,t}$ is a random residual.

3. Price Adjustments

As Hicks points out, there are "sufficient technical rigidities in the process of production to make it certain that a number of entrapreneurs will want to hedge their sales" [27]. Supplies in the near future are largely governed by decisions taken in the past, e.g., the amount of acreage sown. The same thing sometimes happens with planned purchases as well, but "it is almost inevitably rare" since technical conditions give the entrapreneur a "much freer hand" in the aquisition of inputs (largely needed to start new production) than in the completion of outputs (whose process of production has already begun) [27]. For these reasons, one can expect a "tendency for relative weakness on the demand side" of the futures market [p.137].

As Labys and Granger point out, this reasoning suggests that the short hedging and long speculation components of open interest represent the "effective" supply of and demand for future contracts, respectively [49]. Open interest "is the number of futures contracts that have been entered into, but not yet covered by an offsetting contract or fulfilled by delivery" [49]. In our model, this imbalance between the forces of demand and supply is assumed to influence the rate of change in prices. In particular, it is assumed that the rate of change in the futures price of commodity (j), $\Delta P^{(j)}_{t,t+\tau} \equiv P^{(j)}_{t,t+\tau} - P^{(j)}_{t-1,t+\tau}$, is a quadratic function of the difference between the "Hicksian" supply and demand for futures contracts:

$$\Delta P^{(j)}_{t,t+\tau} = \gamma_1^{(j)} \left[({}^{S}q^{(j)}_{t,t+\tau})\right] + \gamma_2^{(j)} \left[({}^{S}q_{t,t+\tau} - {}^{D}q_{t,t+\tau})^2\right] + U_{24,t} \quad (24)$$

where $({}^{S}q_{t,t+\tau} - {}^{D}q^{(j)}_{t,t+\tau})$ is the net "effective" open interest and $U_{24,t}$ is a random variable.

At the heart of both the demand and supply side of the market for forward contracts lies the expectations mechanism determining ${}^{S}P_{t,t+\tau}$. This mechanism is discussed next.

4. Expectations

Borrowing heavily from others [14,18,19,50,57,59,60,92,93] the market expectations mechanism underlying the expected spot price is assumed to be "natural" and dependent on either or some combination of futures prices and changes in crop projections. Specifically, the expected spot price of commodity (j) for time t+τ at time t, $S_{\overline{P}_{t,t+\tau}}^{(j)}$, is assumed to be determined in part by a distributed lag on future prices,

$$\sum_{k=0}^{n^{(j)}} d_{1k}^{(j)} \overline{P}_{t-k,t+\tau}^{(j)}, \tag{25a}$$

and a distributed lag on crop forecasts

$$\sum_{k=0}^{W^{(j)}} d_{2k} \ G_{t-k,t+\tau}^{(j)} \tag{25b}$$

That is

$$S_{\overline{P}_{t,t+\tau}}^{(j)} = \sum_{k=0}^{n^{(j)}} d_{1k}^{(j)} \ \overline{P}_{t-k,t+\tau}^{(j)} + \sum_{k=0}^{W^{(j)}} d_{2k} \ G_{t-k,t-\tau}^{(j)} + u_{25,t} \tag{26}$$

where the d's are coefficients, k denotes the lag, $n^{(j)}$ and $W^{(j)}$ are the maximum lengths of the price and information lags for the $(j)^{th}$ commodity, respectively,[6] and $u_{25,t}$ is a random element.

6. This particular formulation, (25), was chosen in order to obtain a "parsimonious" representation of the expectations mechanism as suggested by Box and Jenkins [6]

5. Market Clearing Equations and Other Constraints

The few equations presented above are subject to constraints analogous to those listed in the spot market model. As in the earlier case, these constraints are self-explanatory and will be summarized here with little further comment.

Market Clearing[7]

$$^{S}q_{t,t+\tau} - {}^{D}q_{t,t+\tau} = \text{net "effective" open interest} \quad (27)$$

Profitability[8]

$$\frac{(1-\delta^{(j)})^{\tau}}{(1+r)^{\tau}} P^{(j)}_{t,t+\tau} - P^{(j)}_{t} - C^{(j)}\tau \geq 0 \quad (28)$$

Price Volatility[9]

$$P^{(j)}_{t,t+k} - P^{(j)}_{t-1,t+k} \leq \psi^{(j)}, \; j=1,\ldots,m \quad (29)$$

Non-Negativity

$$^{S,D}q^{(j)}_{t,t+\tau},\; P^{(j)}_{t,t+\tau} \geq 0 \quad (30)$$

---

7. This relationship follows from the assumption of Hicksian "technical" imbalances discussed in Section III B.3.
8. Same as equation (21) in the spot market
9. The future price of any commodity is not permitted to change by more than a predetermined amount per time period in the United States commodities markets.

6. Summary

In Tables III.6 and III.7, we summarize the general futures market model. The linkages between the Spot and Futures market models are explored in the next sub-Section where the two models are tied together.

TABLE III.6 STRUCTURE OF THE FUTURES MARKET MODEL

Equations

Effective Domestic Demand $$^{D}q^{(j)}_{t,t+\tau} = q_1^{(j)}\left[({}^{S}P_{t,t+\tau} - P_{t,t+\tau}),\ \sigma_{{}^{S}P,P},\ r'\right] \tag{22}$$

Effective Domestic Supply $$^{S}q^{(j)}_{t,t+\tau} = q_2^{(j)}\left[({}^{S}P_{t,t+\tau} - P_{t,t+\tau}),\ \sigma_{{}^{S}P,P},\ S_t\right] \tag{23}$$

Price Adjustment $$\Delta P^{(j)}_{t,t+\tau} = \gamma^{(j)}\left({}^{D}q^{(j)}_{t,t+\tau} - {}^{S}q^{(j)}_{t,t+\tau}\right) + \gamma_2^{(j)}\left(q_{t,t+r} - {}^{S}q^{(j)}_{t,t+r}\right)^2 \tag{24}$$

Expectations $$^{S}P^{(j)}_{t,t+\tau} = \sum_{k=0}^{n^{(j)}} d^{(j)}_{1k}\, P^{(j)}_{t-k,t+k} + \sum_{k=0}^{W^{(j)}} d_{2k}\, \Delta G^{(j)}_{t-k,t+\tau} \tag{25}$$

Identities and Inequality Constraints

Market Cleaning $$^{S}q^{(j)}_{t,t+\tau} - {}^{D}q^{(j)}_{t,t+\tau} = \text{net "effective" open interest} \tag{27}$$

Profitability $$\{(1-\delta^{(j)})^{\tau}/(1+r)^{-\tau}\}P^{(j)}_{t,t+\tau} - P^{(j)}_{t} - C^{(j)}\tau \geq 0 \tag{28}$$

Unbiased Expectations $$\sum_{k=1}^{n^{(j)}} d^{(j)}_{1k} = 1 \tag{26}$$

Price Volatility $$P^{(j)}_{t,t+\tau} - P^{(j)}_{t-1,t+\tau} \leq \psi^{(j)}_{\tau} \tag{29}$$

$$^{S}q^{(j)},\ {}^{D}q^{(j)},\ \psi^{(j)} \geq 0 \tag{30}$$

TABLE III.7 MNEMONICS FOR TABLE III.6

${}^{D}q^{(j)}_{t,t+\tau}$	=	The effective demand for forward sales contracts of commodity (j) at time t for time t+τ.
${}^{S}q^{(j)}_{t,t+\tau}$	=	The effective supply of forward sales contracts of commodity (j) at time t for time t+τ.
$P^{(j)}_{t,t+\tau}$	=	The futures price of commodity (j) at time t for time t+τ.
${}^{S}P^{(j)}_{t,t+\tau}$	=	The "expected" spot price of commodity (j) at time t for time t+τ.
$\sigma_{S_{P,P}}$	=	The variation between expected spot and futures prices.
$\Psi^{(j)}_{\tau}$	=	The maximum allowable fluctuation in the futures price of commodity (j) with a time interval of τ.
$c^{(j)}$	=	The marginal storage cost of commodity (j).
r'	=	The rate of interest on commodity credit.
r	=	The rate of discount.
$\delta^{(j)}$	=	The rate of decay of commodity (j).
S_t	=	The domestic stocks of commodities at time t.

C. The Interaction of the Spot and Futures Markets

In the following paragraphs, the linkages between the spot and futures market models are explored and the models coupled into a single simultaneous system. This interactive system then is used to analyze the movements in futures and spot prices. Here, special emphasis is given to the impacts of world trade, Government controls and the timing and accuracy of crop projections. The discussion, of course, is pedagogical in character. That is to say the analysis is hypothetical and is presented to illustrate the type of policy analyses to be extracted from the empirical results.

1. Structural Interdependencies

The linkages between the spot and futures models have been indicated in Sections III.A and III.B above. The policy implications of these linkages, however, warrant their reiteration and some elaboration on their analytical impacts.

One of the most important obvious linkages is that of spot prices to futures prices. The dependence of spot prices on futures prices suggests that "backwardation", information improvement, and risk aversion may exert a significant influence on both spot and futures prices. Thus, in the final analysis, our structures make it possible to measure the impacts of improvements in crop forecasts on both spot and futures prices. The magnitudes, and timing of these impacts, of course, are an empirical question.

Another important and obvious linkage is the dependence of the futures market process on current domestic stocks specified in the spot market. These stocks, it will be recalled, are determined in part by government stockpile policy operations, and net exports, among other factors. It follows that futures prices will be influenced by factors such as exchange rates, transport costs, net export limitations, and government stockpile operations.

In addition to these obvious linkages, there are a few constraints that warrant special mention. First, the profitability constraint ensures that marginal storage and transportation costs will impact both spot and futures prices. Second, the institutional constraints on price volatility will dampen movements in spot prices and, of course, limit movements in futures prices. Third, the lags introduced in the expectations mechanism and stock adjustment relationships imply that spot and futures prices both will adopt to new crop forecasts over time and, therefore, earlier and/or better forecasts will impact on both the spot and futures markets over time.

The full policy implications of this simultaneous interaction between the two markets can best be illustrated by solving the system and illustrating the use of the model in a policy control context. This is done in the next subsection.

2. Simultaneity, Causal Ordering, and Policy Analysis

To illustrate the policy implications of the model we have developed, consider the simplification:

$$Q_t = \Gamma Q_t + \beta_1 Z_{1t} + \beta_2 Z_{2t} \tag{31}$$

where

Q_t	=	n x 1	vector of dependent variables
Γ	=	n x n	matrix of structural coefficients on the jointly dependent variables
Z_{1t}	=	p x 1	vector of non-policy exogenous variables
β_1	=	n x p	matrix of structural coefficients on the non-policy exogenous variables
Z_{2t}	=	a x 1	vector of policy control exogenous variables
β_2	=	n x a	matrix of structural coefficients on the policy control exogenous variables

The term ΓQ_t represents the interdependence relations in the full model. The term $\beta_1 Z_{1t}$ captures the impact of non-policy variables, i.e., variables over which the government and other regulatory bodies have no direct control. The last term $\beta_2 Z_{2t}$ describes the impact of the policy control variables on the equilibrium prices and quantities, Q_t.

Solving this system yields the reduced form model:

$$Q_t = \phi_1 Z_{1t} + \phi_2 Z_{2t} \tag{32}$$

where $\phi_1 = [I-\Gamma]^{-1}\beta_1$, and $\phi_2 = [I-\Gamma]^{-1}\beta_2$

We are now ready to illustrate the policy applications of the model. Suppose that some, or all, of the dependent variables Q_t are "targeted" by administrators to take on certain "desired" values. Let us denote these "target" values Q_t^*. The question of importance to the administration, of course, is what values of the control variables are required in order to hit the target. Under conditions of perfect control, this objective could be stated

$$Q_t^* - Q_t = 0 \tag{33}$$

That is the difference between the actual Q_t and desired Q_t^* values of the dependent variables should be zero.

Substituting (32) into (33) and rearranging terms, we see that the optimal (in the sense of equation 33) values of the control variables Z_{2t} will be some function of the difference between the target values Q_t^* and the value of the dependent variables if there was no control at all, $\phi_1 Z_{1t}$.

That is

$$Z_{2t} = (\phi_2'\phi_2)^{-1} \phi_2' [Q_t^* - \phi_1 Z_{1t}], \tag{34}$$

where

ϕ_2' = transpose of ϕ_2.

Assuming $|(\phi_2' \phi_2)| \neq 0$; it is possible to solve for the set of optimal control decision rules, (34), for each alternative target constellation selected by the administrators, and to assess their feasibility.

Before summarizing the full model, two points must be noted. First, the above discussion assumes Z_{1t} and Z_{2t} are independent.

This, of course, is an empirical question and hopefully there will be enough analytical resolution in the model to disentangle their combined influences. Second, it will be possible to analyze improved crop forecasts as either a non-control variable (a Z_{1t} type variable) or as a control variable (a Z_{2t} type variable). That is, it is conceivable that one will be able to measure the control benefits from improved crop forecasts against, say, changes in Government purchases or sales of commodities.

3. Summary of the Full Model

In Table III.8, we summarize the structure of the combined spot and futures market models. The equations are the same as those presented in Sections III.A and III.B and are presented here without further comment to illustrate the simultaneous nature of the two models. In Figure III.1 we present a flow diagram overview of the full model. Here, the arrows devote the principal direction of causality and the structural linkages between the various relationships. The simultaneity of the model can be verified easily by starting at any point in the mainstream of the behavioral structures and "following the arrows" full course all the way back to the original starting point.

TABLE III.8 STRUCTURE OF THE SPOT AND FUTURES MARKETS

Private Domestic Demand	${}^{DD}q_t^{(j)}$	$= D_1(P_t, P_{t,t+\tau}, X_t) + u_{2t}$	(2a)
Domestic Production	${}^{DS}q_t^{(j)}$	$= \left[\gamma_2^{(j)} f_2(\bar{P}_{t-\tau,t}, P_{t-\tau,t-\tau}) + f_2(r_t)] + (1-\gamma_2^{(j)})\, {}^{DS}\lambda_{t-1}^{(j)} + u_{11,t}\right]^{r_t^{(j)}}$	(14)
Domestic Private Stock	${}^{D}S_t^{(j)}$	$= \gamma_1^{(j)} s(S_t, P_t, \bar{P}_{t,t+\tau}, C) + (1-\gamma_1^{(j)})\, {}^{D}S_{t-1}^{(j)} + u_{10,t}$	(10)
Net Export Demand (±)	${}^{DX}q_t^{(j)}$	$= g(P_t, \bar{P}_{t,t+\tau}, P_t^W, \tilde{P}_{t+\tau}^W, Y_t) + {}^{GX}q_t^{(j)} + u_{3t}$	(3)
Net Export Constraints	${}^{DX}q_t^{(j)}$	$\leq \begin{cases} E_{1t}^{(j)}; & {}^{DX}q_t^{(j)} > 0 \\ E_{2t}^{(j)}; & {}^{DX}q_t^{(j)} < 0 \end{cases}$	(17)
Total Demand	${}^{D}q_t^{(j)}$	$= {}^{DD}q_t^{(j)} + {}^{DX}q_t^{(j)} + {}^{G}q_t^{(j)}$	(10c)
Market Clearing	${}^{DS}q_t^{(j)} - {}^{D}q_t^{(j)}$	$= \Delta S_t^{(j)}$	(16)
Total Stocks	$S_t^{(j)}$	$= {}^{D}S_t^{(j)} + {}^{G}S_t^{(j)}$	(10b)
Effective Futures Demand	${}^{D}q_{t,t+\tau}^{(j)}$	$= q_1^{(j)}\left[({}^{S}P_{t,t+\tau} - P_{t,t+\tau}), \sigma_{{}^{S}P,P}, r\right]$	(22)
Effective Futures Supply	${}^{S}q_{t,t+\tau}^{(j)}$	$= q_2^{(j)}\left[({}^{S}P_{t,t+\tau} - P_{t,t+\tau}), \sigma_{{}^{S}P,P}, S_t\right]$	(23)
Futures Price Adjustment	$\Delta P_{t,t+\tau}^{(j)}$	$= \gamma_1^{(j)}\left({}^{S}q_{t,t+\tau}^{(j)} - {}^{D}q_{t,t+\tau}^{(j)}\right) + \gamma_2^{(j)}\left({}^{S}q_{t,t+\tau} - {}^{D}q_{t,t+\tau}^{(j)}\right)^2$	(24)
Expectations	${}^{S}P_{t,t+\tau}^{(j)}$	$= \sum_{k=0}^{n^{(j)}} d_{1k}^{(j)} P_{t-k,t+\tau}^{(j)} + \sum_{k=0}^{W^{(j)}} d_{2k} \Delta G_{t-k,t+\tau}^{(j)}$	(26)

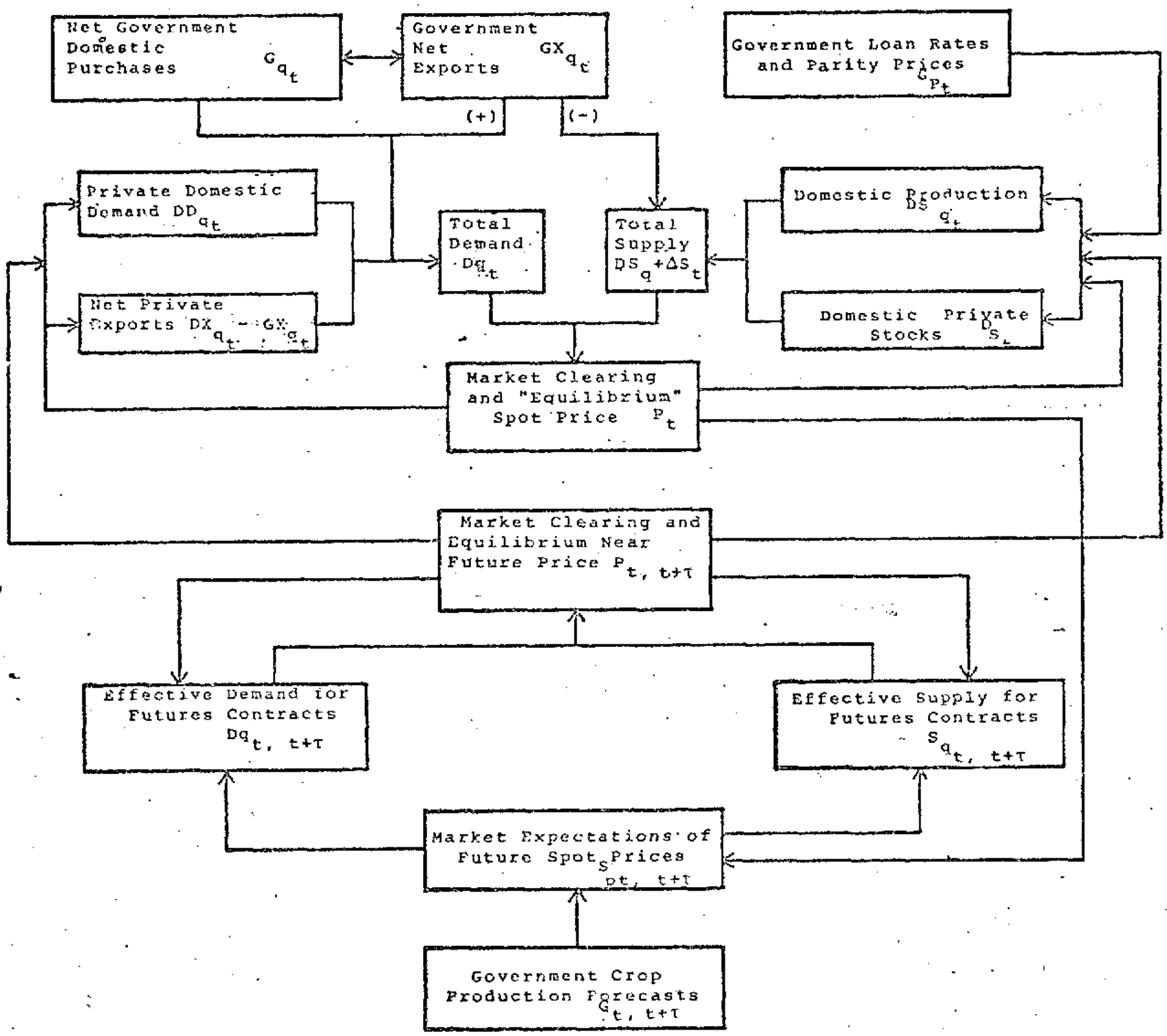


Figure III.1 Flow Diagram of the Spot and Futures Markets Models for Agricultural Commodities

IV. A MODEL OF THE COMMODITIES MARKETS: EMPIRICAL RESULTS

In this Section, we summarize the empirical estimates of our model for two commodities, soybeans, and wheat. The material is presented in three parts. First, we outline the overall estimation strategy and the methodological tools to be employed. Next, we specify the particular structures to be used in the test cases. Included in this Section are assessments of the data and a summary of the empirical results. Finally, we set forth the major empirical findings and underscore some general results concerning the distinction between the long- and short-run, the importance of crop forecast information on commodity prices, and the influences of the foreign sector and government policy on the domestic wheat and soybean markets.

A. Estimation Strategy

In the following paragraphs, we discuss the three major methodological problems encountered in this study and our approach to their resolution. These issues are: the identification of, and distribution between, long- and short-run patterns of behavior; the identification of the dynamic structures to be estimated, and the simultaneous estimation of the interdependent structures.

1. Frequency Band Model Building: A Distinction Between The Long- and Short-Run

The model developed in the preceding section did not specify the length of the decision interval under consideration (days, weeks, etc.). Because the causal structure of a decision process may differ with respect to the time perspective of the decision, decision rules conventionally are defined relative to a specific time horizon. The latter assertion, of course, follows directly from the tenets of microeconomic theory where the distinction made between the long- and short-run is, for the most part, the number, way, and type of variables that enter a firm's or consumer's criterion function. Dynamic considerations suggest an additional point of equal importance: a change in the decision perspective may completely alter not only the <u>nature</u> but also the direction of causality. Although a detailed analytical summary of these points is beyond the scope of this paper, some examples of changes in <u>causality</u> and <u>feedback</u> in the context of this study will be presented in order to illustrate the potential importance of the problem.

Let us assume that a commodity dealer can distinguish between the short-run seasonal and irregular market patterns and long-run trend and cyclical movements. Economic theory tells us that the decision to expand or contract storage capacity in the long-run, for example, will depend, in part, on the expected trends and volatility in total demand for the commodity(ies). The profile of future total demand, of course, is likely to be a function of trends in macroeconomic forces.

Thus, long-run macroeconomic considerations are likely to <u>cause</u> changes in storage capacity; that is, determine, in part, long-run storage decisions. On the other hand, the dealer's short-run decision are likely to focus on production rates, inventory levels, etc., given some level of storage capacity. That is to say, the macroeconomic variables that determine the dealer's long-run decisions are not likely to have the same influence (causality), if any, on his short-run decisions. Obversely, the influence of an aberration such as an unexpectedly poor crop may not have as strong an influence on his long-run decisions as on his short-run decisions.

Although the above example illustrates differences in causality, owing to changes in the decision time horizon, it does not illustrate changes in the direction of causality. In order to illustrate this problem,

> "...Consider two stock exchanges in some country, one of major importance (A) and the other of lesser importance (B). Clearly, B will be likely to follow all the fluctuations, both long-run and short-run, of A, and so we have A=>B (variation in A "maps into" B). However, A will be unlikely to be affected by short-run fluctuations of B, but may be concerned by the long-run fluctuations. Thus, if a subscript L denotes the low-frequency component and a subscript H, the high-frequency component, we may have $B_L => A_L$, $B_H \not=> A_H$. Thus, in this example, feedback will only occur in the low frequency range."[11]

[11] Granger & Hatanaka, <u>Spectral Analysis of Economic Time Series</u> (Princeton, NJ, Princeton University Press, 1964) p.123. For a more sophisticated presentation of this concept, see G.M.Jenkins and D.G.Watts, <u>Spectral Analysis and Its Applications</u> (Holden-Day, San Francisco, 1969) pp.398-450.

The crucial point of this example is that a segment of economic activity may be jointly dependent with some other segment of economic activity for long-run decisions (L), but independent of that segment for short-run decisions (H). That is to say, the causality between economic "players" may be simultaneous for one decision interval, but uni-directional for another.

Although these examples do not prove that decision processes necessarily change with the length of the decision interval, they do suggest that separate relationships should be considered <u>for every clearly delineated decision interval</u>.

Following the approach taken by Labys and Granger [49], and suggested by Granger and Hatanaka [22], each variable in the model presented above is separated into a long-run trend/cycle component and a short-run seasonal and irregular component. Long-run trend/cycle and short-run seasonal and irregular models then are estimated separately and the complete time series profile of the model obtained by combining the two distinct "frequency-band" models.

Following generally accepted practice, we have employed centered moving averages as the low-pass filter (F_L) to isolate the trend/cycle movements. Seasonal movements were then obtained by subtracting the trend/cycle component from the original series in each case, with the appropriate deletions at the ends of the series. This approach bears some family resemblance to more common ratio-to-moving-average filtering techniques, such as the Census X-11 method, but does yield slightly different time series content. Of course, the results of the filters we did use were carefully checked using spectral techniques [43] and, as described in detail in Section IV, B, below, were found to filter the desired frequencies without disturbing surrounding frequencies or introducing spurious ones.[12]

2. Dynamic Structures and Their Estimation

In economics, the relationship between a set of explanatory variables and the dependent variable rarely is instantaneous. Instead, the response tends to build up dynamically over time. In general, these relationships are explained by some combination of lagged dependent variables and distributed lags on other explanatory variables (a mixed autoregressive and moving average process). Often, these lag structures contain an infinite number of parameters and, for practical purposes, the relationships must be replaced by finite parameter, i.e., "parsimonious" approximations [6]. Guarding against the possibility of encountering an unwieldy number of parameters, we follow Box and Jenkins [6] and attempt to capture the typical trend/cycle and seasonal relationships of the form,

---

[12]The techniques employed here are discussed in an ECON technical paper addressing many of the methodological issues raised in this study.

$$\gamma(L)\nabla^{d}F_{L}(Z_{it}) - \sum_{\substack{j-1 \\ j\neq i}}^{k} \theta_{j}(L)\nabla^{d}F_{L}(Z_{jt}) = \omega^{-1}(L)\eta(L)\epsilon_{it}^{T} , \tag{35}$$

$$\alpha(L)(1-L^{12})F_{H}(Z_{it}) - \sum_{\substack{j=1 \\ j\neq i}}^{m} \beta_{j}(L)(1-L^{12})F_{H}(Z_{jt}) = \phi^{-1}(L)\Psi(L)\epsilon_{it}^{s} , \tag{36}$$

respectively, where γ, θ, ω, η, α, β, and Ψ are polynominal functions of the lag operator L, $L(Z_t)=Z_{t-1}$; ∇ is a backward difference operator, $\nabla Z_t=Z_t-Z_{t-1}$, used to enforce apparent stationarity; γ^{-1} and ω^{-1} are the inverses of γ and ω, respectively; ϵ_{it}^{T} and ϵ_{it}^{s} are stationary disturbance terms with null cross- and auto-coveriance; and L^{12} is a 12-month lag operator, $L^{12}(Z_t)=Z_{t-12}$.

The left side of Equations (35) and (36) describe the transfer function portion of the empirical structures, while the right side describes the "noise" models. The noise models have been built onto the residuals from the transfer function models on the assumption that, in a dynamic framework, economic behavior includes a serially correlated stochastic term. These noise models are assumed to be of the form,

$$e_{it}^{T} = \omega^{-1}(L)\eta(L)\,\epsilon_{it}^{T}, \tag{37}$$

and

$$e_{it}^{s} = \phi^{-1}(L)\Psi(L)\,\epsilon_{it}^{s}, \tag{38}$$

where e^T_{it} and e^s_{it} are the residuals from the trend/cycle and seasonal transfer function models, respectively.[13]

3. An Approach to System Estimation

As noted in Section III.C, the model presented includes a number of jointly dependent endogenous variables in the structures. These interdependencies can lead to serious estimation problems if single equation least squares methods are used [58]. However, not all estimation techniques for interdependent systems may be desirable. Theil's two-stage least squares [58], maximum likelihood with full or limited information [58], and the instrumental variables approach of Jorgenson [58] typically require the use of so-called "reduced form" equations. For meduim and larger sized models, these reduced form equations can be mammoth regressions that exceed the available degrees of freedom. Moreover, even when there are sufficient degrees of freedom using the reduced form equations, these methods require an heroic number of zero correlation assumptions [58] in order to determine the structural parameters. One method that avoids these chortcomings, and provides consistent estimators with two-stage least squares efficiency, is the Fixed Point method of Wold [58, 91]. In essence, this method estimates the structural parameters within the structures, using an iterative least squares procedure. This

[13] The estimation of these structures is based, in part, on a variation of the approach developed by Box & Jenkins [6], and is described in detail in an ECON technical paper.

method was adopted here primarily because of its "zero correlation" assumption efficiency.[14]

B. Empirical Results

Our preliminary empirical tests of the model developed in Section III are summarized below. The results are presented in two parts: one for the Soybean market and the other for the Wheat market. Each of these parts, in turn, is divided into four subsections: the first highlights the institutional characteristics of the market, the second describes the estimating equations and explanatory variables, the third summarizes the data, and the fourth summarizes the estimation results.

1. Soybeans

a. Institutional Overview

The soybean market in the United States has grown rapidly since the end of World War II increasing from production of 200 million bushels a year and self-sufficiency in 1946 to over 1 billion bushels a year and 95% of the world market today [ ]. The domestic soybean crop is harvested from September to November. The earliest USDA crop estimates are available in March and are made through November owing to reporting lags. Perhaps the most important characteristic of soybeans relative to the general model presented earlier is

[14] This method also is discussed in further detail in an ECON technical paper.

the transformation of soybeans into other commodities, i.e., soybean meal and soybean oil, each of which have somewhat different domestic and foreign demand profiles. No attempt is made to analyze these markets in detail. Rather, we focus on soybeans and include the impacts of the soybean meal and oil markets on soybeans through their prices.

Another important characteristic of the soybean market is that the government has not been as active in this market as it has been, for example, in the wheat market. However, soybean planting decisions appear to have been influenced indirectly through government constraints and operations in other markets. For example, the acreage allocated to soybeans may be viewed as foregone acreage for other crops and, therefore, government soil bank and CCC sale and loan policies for wheat may be important influences on soybeans indirectly.

Soybean futures, as well as soybean oil and meal, are traded principally on the Chicago Board of Trade. The contract months are September, November, January, March, May, July, and August. The "standard contract" is for 5000 bushels. That is, all trades are made as integer multiples of 5000 bushels. Hence, three contracts would mean 15,000 bushels. Price is quoted in cents per bushel. In the futures market, the smallest allowable daily price fluctuation is 1/8 cent per bushel or $6.25 per contract. The maximum allowable daily range is 20 cents per bushel and the maximum fluctuation (net daily change from the closing price of the previous day) is 10 cents per bushel. The implied maximum monthly price fluctuation is about $2.20 per bushel.

Soybean oil futures are traded in contracts of 60,000 pounds and prices are given in cents per pound. The lowest recorded price fluctuation is 1/100 of a cent per day and the largest price fluctuation is one cent per pound or $600 per contract. The implied monthly maximum fluctuation is $13,200 per contract.

Soybean meal futures are traded in contracts of 100 tons and prices are quoted in cents per ton. The minimum and maximum daily price fluctuations are 5 cents and $5 per ton, respectively. The maximum monthly price fluctuation is $100 per ton. These price constraints are not in force in the spot market on and after the first "notice" day, i.e., on and after the first day of the contract month.

With these characteristics in mind, we will turn to the soybean model, the data used, and the estimation results.

b. The Model

The heart of the soybean model consists of the eight estimating equations presented in Table IV.1. The numbers to the right of the eight equations denote their introduction in Section III. The functional forms are taken to be linear for the preliminary empirical study. Moreover, as can be seen, the equations are in semi-reduced form. That is, a number of

Table IV.1 Principal Semi- Reduced Form Estimating Equations
For The Spot and Futures Wheat Market Model

Private Domestic Demand (Spot)	$^{DD}q_t^{(j)}$	$= \sum_{k=0}^{K} \sum_{i=1}^{m} h_{1ik} P_{t-k}^{(i)} + \sum_{k=0}^{K} \sum_{i=1}^{m} h_{2ik} P_{t-k,t+T-k}^{(i)} + \sum_{k=0}^{K} \sum_{i=1}^{n_1} h_{3ik} X_{it-k} + h_o + \sum_{k=1}^{K} {}^{DD}q_{t-k}^{(i)}$	(2a)
Domestic Production (Spot)	${}^{S}q_{t}^{(j)}/Y_t^{(j)}$	$= \sum_{i=1}^{m} f_{2i} \bar{P}_{t-12,t}^{(i)} + \sum_{i=1}^{m} f_{3i} P_{t-12,t-12}^{(i)} + \sum_{i=1}^{m} f_{4i} P_t^{(i)} + \sum_{o}^{m} (1-\gamma)_i \, {}^{S}q_{t-12}^{(i)}/Y_{t-12}^{(i)} + f_o$	(14)
Net Export Demand (Spot)	${}^{DX}q_t^{(j)}$	$= \sum_{k=0}^{K} \sum_{i=1}^{m} g_{1ik} \left(P_{t-k}^{(i)} - P_{t-k}^{W(i)}\right) + \sum_{k=0}^{K} \sum_{i=1}^{m} g_{2ik} \left(P_{t-k,t+T-k}^{(i)} - \bar{P}_{t-k,t+T-k}^{W(i)}\right) + \sum_{k=0}^{K} \sum_{i=1}^{m} g_{3ik} \, TT_{t-k}^{(i)} + \sum_{k=0}^{K} \sum_{i=1}^{m} g_{4ik} \, TR_{t-k}^{(i)} + \sum_{k=0}^{K} {}^{DX}q_t^{(i)} + g_o$	(3)
Domestic Private Stocks (Spot)	${}^{D}S_t^{(j)}$	$= \sum_{i=1}^{m} s_{1i} P_t^{(i)} + \sum_{i=1}^{m} s_{2i} \bar{P}_{t,t+T}^{(i)} + \sum_{i=1}^{m} (1-\gamma)_i \, {}^{D}S_{t-1}^{(i)} + s_o$	(10)
Equilibrium Price (Spot)	$P_t^{(j)}$	$= \sum_{k=0} \sum_{i=1}^{m} \rho_{3i\,k} \bar{P}_{t-12-k,t-12}^{(i)} + \sum_{k=0} \sum_{i=1}^{m} \rho_{4i\,k} P_{t-12-k,t-12-k}^{(i)} + \sum_{k=1} \rho_{t+12}^{(i)} \quad \sum_{k=0}^{K} \rho_{5k} \, {}^{DX}q_{t-k} + \sum_{k=0}^{K} \rho_{6k} \, {}^{DD}q_{t-k} + \sum_{k=0}^{K} \sum_{i=1}^{n} \rho_{7ik} X_{it-k} + \sum_{k=0}^{K} \sum_{i=1}^{m} \rho_{8ik} \left({}^{S}q_{t-12-k}^{(i)}, Y_{t-12-k}^{(i)}\right) + \sum_{k=0}^{K} \rho_{9ik} \, {}^{D}S_{t-k}^{(i)} + \rho_o$	(2a, 14, 13, 3, 16)
Demand Effective (Futures)	${}^{D}q_{t,t+T}^{(j)}$	$= \sum_{i=1}^{m} \sum_{k=0}^{K} q_{1ki} P_{t-k,t+T}^{(i)} + \sum_{i=1}^{m} \sum_{k=0}^{K} q_{2ki} \sigma_{ki} + \sum_{i=1}^{m} \sum_{k=0}^{K} q_{3i} r_{t-k}^{\prime(i)} + \sum_{k=1}^{K} {}^{D}q_{t,t+T-k}$	(22, 25)
Supply Effective (Futures)	${}^{S}q_{t,t+T}^{(j)}$	$= \underbrace{\sum_{i=1}^{m} \sum_{k=0}^{K} q_{4ki} P_{t-k,t+T}^{(i)}}_{\text{not effective}} + \underbrace{\sum_{i=1}^{m} \sum_{k=0}^{K} q_{5ki} \sigma_{ki}}_{\text{not effective}} + \sum_{i=1}^{m} \sum_{k=0}^{K} q_{6ki} S_{t-k}^{(i)} + \sum_{k=1}^{K} {}^{S}q_{t-k,t+T-k}$	(23, 25)
Price Adjustment (Futures)	$\Delta P_{t,t+T}^{(j)}$	$= \sum_{k=0}^{K} \gamma_{1\,k}^{(j)} \left({}^{D}q_{t-k,t+T-k}^{(j)} - {}^{S}q_{t-k,t+T-k}^{(j)}\right) + \sum_{k=0}^{K} \gamma_{2\,k}^{(j)} \quad = \sum_{k=0}^{K} \gamma_{1\,k}^{(j)} \left({}^{D}q_{t-k,t+T-k}^{(j)} - {}^{S}q_{t-k,t+T-k}^{(j)}\right) + \sum_{k=1}^{K} \Delta P_{t-k,t+T-k}^{(j)}$	(24)

equations have been combined into a smaller set of equations. In this way, the number of interdependencies has been reduced. However, not all of the interdependencies have been removed by algebraic manipulation and the essence of the structural dialogue between the spot and futures markets has been maintained.[15]

At least two important characteristics of these substitutions warrant some mention. First, the marriage of Equation (25), spot price expectations, with the futures demand and supply equations, (22) and (23), respectively, introduces distributed lags on futures prices, government forecasts and the variations in these factors, into the supply and demand for futures contracts. Secondly, by substituting the relationships for domestic production and demand, into the spot market clearing equation, the implicit equilibrium spot market price becomes a function of the factors influencing domestic production and demand, including either directly or indirectly futures prices and crop projections.

A few other comments about the estimating equations in Table IV.1 also are in order. First, the terms f_o, h_o, g_o, etc., are the "intercepts" in the various equations. Second, the number of commodities, m, does not exceed five. These include: soybeans, wheat, soybean meal, soybean oil and corn.

---

[15] It is in this sense that the equations in Table IV.1 are said to be semi-reduced form (not fully reduced).

In addition to the analytical transitions mentioned above, there are a few empirical characteristics that also should be noted. First, domestic production in the spot market cannot be estimated using "pure" monthly data since quarterly or annual data are the only ones readily available from the USDA on harvested acreage and yield. Thus, it was necessary to construct a monthly series for domestic production. This was done by prorating the annual crop over the harvest months according to their historical monthly harvest pattern.[16] The yield figures for any one year are treated here as exogenous and are applied to each harvest month equally. To be sure, the yield distributions within a year fluctuate from year to year owing, in part, to purely random factors. Consequently, our construct is at best an approximation to "reality". Secondly, monthly stocks of soybeans were generated from a blending of annual and monthly data. Statistical discrepancies emerge here also. These errors, however, are small.[17] Third, there are a number of futures price contracts, (one monthly series for each contract month), but only aggregate measures of the quantity of futures contracts. For this reason, a single futures price index must be used. The approach used

---

[16] The actual construction of the series is presented in Section IV.C.

[17] Ibid.

here follows the common practice of constructing a "near futures price" index. Specifically, the method employed in this study is the one suggested by Cootner [12] and used extensively by commodity traders and brokers.[18] Finally, domestic consumption is available only in quarterly totals. The constructed monthly series distributed these totals evenly within the quarter.

No doubt the approximations mentioned above dilute the full potential of the model hypothesized in Section III. That is not to say, however, that the results will be unintelligible or highly inaccurate. The approximations made here all are in the "right direction" and will not introduce order of magnitude errors into the estimation results. At most, the errors introduced here will be of second order significance, e.g., the length of the distributed lag on some variable or the structural significance of observed autocorrelation in the residuals. To be sure, these problems are important and their resolution is a worthy undertaking. Nevertheless, the principal empirical objectives still are well within reach: to identify and measure the cross impacts between the spot and futures markets, to measure the importance of market information in the form of crop forecasts, to identify and measure the role of net exports

[18] The actual construction of the series is presented in Section IV.C.

on spot and futures prices and to distinguish between long- and short-run patterns of behavior.

Before turning to our results, we further summarize the data, their strengths, weaknesses, transformations, and availabity.

c. The Data

In the following paragraphs, we summarize the major characteristics of the data used in this study and the sources of those data. As mentioned earlier, the data needed to estimate the soybean model do not all exist in the most convenient form if they exist at all. These data limitation only can be overcome through the use of surrogates and data transformations. The most important of these are listed below.

First, since the total volume of futures contracts and open interest are not categorized as to the contract month (of which there are seven; January, March, May, July, August, September, and November), some form of futures price index number must be constructed. The index used here was first suggested by Cootner [12] and commonly is called the "near futures price". In essence, this price index ties the prices of the various futures contracts to the contract month preceding the harvest. It is assumed that the trader acquires a position at this time and carries it through the following year switching forward to the next futures month only at the end of those months preceding the contract maturation months. Since the soybean harvest is from September through November, the "linking" contract month is August. There are seven contract months for soybeans; August, September, November, January, March, May, and July. Traders are assumed to take positions in the September, November, January, March, May, and July contracts. At the end of the months prior to these contract months, the dealer is assumed to shift forward to the next August contract. Thus, for example, if P_i is the price of the January future at the end of December, and q_i is the price of the August future, at the end of December, the price used for December would be P_i and the price used for January would be $P_i +$ $(q_{i+1} - q_i)$.

Second, futures prices are a simple average of the months' high and low price and spot prices are monthly average prices.

Third, domestic consumption was only available as quarterly totals. Month figures were generated by uniformly distributing these amounts over the intraquarterly months.

Fourth, monthly world prices were constructed from trend lines fitted to annual data. A similar procedure also was used to obtain monthly shipping costs of grain and soybeans in international trade. This method was chosen to avoid the discontinuities introduced by simple uniform annual distributions.

Fifth, the annual soybean harvest was distributed evenly over the harvest months.

Sixth, the crop forecast data used are USDA projections and forecast inaccuracy was measured by the average absolute values of the forecast errors at different lead times over the estimation period considered. In general, each times series of forecast error variations takes on a saw tooth appearance with the largest variation farthest from the harvest month and declining to the smallest forecast error variation in the harvest month. This pattern was repeated each year.

Seventh, FAO per capita food production indices were used an an indicator of net foreign demands for food. These annual index numbers were converted to monthly indices using time polynomial regression estimates.

Eighth, the monthly consumer price index of the Department of Commerce was used as the index of general rates of inflation. The monthly price indices for meat animals and farm production items also are those reported by the Department of Commerce.

Ninth, a shift in open interest occurred in 1960. After 1960, the Commodity Exchange Authority reported open intent only for the Chicago market and not all U.S. markets as was true prior to 1960. However, since 99% of the U.S. market activity was in Chicago, no special adjustments have been made to the data.

Tenth, the effective monthly demand and supply of futures contracts were constructed from bi-monthly figures reported to the Commodity Exchange Authority on the 15th and last day of

C - 2

each month. Here, the bi-monthly figures were summed to obtain the monthly totals.

Eleventh, private monthly exports were obtained by subtracting CCC exports from total monthly U.S. exports.

Twelfth, private stocks were approximated using data supplied to the Commodities Research Bureau by over 450 of the largest holders of inventories and adjusting their quarterly totals to equal the quarterly total private stocks reported by the USDA.

Finally, monthly private domestic demand (disappearance) also was created by adding, or subtracting as the case may be, monthly production and changes in CCC stocks (CCC demand) to monthly changes in total monthly U.S. stocks. This was done as a check and alternative to the other approach described above.

The following publications constitute the major sources of data used in the estimation model.

- <u>Commitments of Traders in Commodity Futures</u> [9]. This source contains monthly figures for total futures trading volume, open interest, and long and short hedging and speculative positions.
- The <u>Statistical Annual of The Chicago Board of Trade</u> [8]. The source contains monthly U.S. stocks of wheat, corn, and soybeans.

- Food Grain Statistics. [84] This USDA publication reports monthly CCC exports and quarterly U.S. supply and disappearance.
- Crop Production Reports, Prospective Plantings Report, and Annual Summary. [83]. These publications give monthly planting intentions, acreage, yield for all crops including soybeans.
- Fats and Oils Situation Reports [83]. This data source includes soybean oil prices, the prices of other oils, expoerts, and government buying and selling operations.
- The Feed Situation Report [87]. This publication includes price, export and government operations data for soybean meal, and competing animal feeds.
- The Monthly Report of The Federal Reserve System [5]. This publication contains weekly and monthly credit and interest rate statistics.
- The Survey of Current Business [89]. This publication includes monthly GNP, and commodity price index numbers, among other statistics.
- The Commodity Yearbook of the Commodity Research Bureau [10]. This privately published document contains monthly stock, price, and export data for all major commodities.

- Food and Agricultural Organization: Production Yearbook [80]. This United Nations publication includes annual food production and population figures for all major regions of the world as well as index numbers of their per capita food production.
- Food and Agricultural Organization: Trade Yearbook [81]. This United Nations publication reports annual trade figures for all major regions of the world. Included here are annual imports and exports, shipping rates, and world prices.

d. Estimation Results

In general, the empirical results are most encouraging. Following the estimation methods described above the resulting estimates are highly accurate. The squared correlation coefficients in the trend equation all lie above .90 and the Durbin-Watson "d" statistics lie between 1.95 and 2.01. Moreover, the auto-and cross spectral representations of the residuals do not exhibit significant power concentration or coherences at the 20% level. Likewise, the residuals from the seasonal equations do not exhibit significant auto-or cross-spectral power concentration and the "d" statistics lie between 1.80 and 1.96. However, it must be noted that the squared correlation coefficients for the seasonal equations are not as high as those for the trend equation. Here, the R^2 lie between .58 and .76. These results are not disturbing when one realizes that the seasonal components contain most of the noise in the series.

In Table IV.2 we present the major statistically significant impulse response elasticities estimated in the soybean model. The elasticities represent the full impact of an impulse on the indicated response variable. That is, the elasticities reflect the sum of the "lagged" coefficients on the impulse variables.

For the most part the economic results correspond to what we could expect from economic theory. Nevertheless each set of elasticities warrants some preliminary comment here.

Net Private Exports: In the long-run net private exports of soybeans are most responsive to changes in Asian per capita food production: a result that parallels the quantity consumption of U.S. soybean exports. Not surprisingly, U.S. soybean exports are very responsive to European per capita food production as well. It appears, however, that foreign demand is not irresponsive to price as indicated by the high elasticity of -.84. Preliminary investigation suggests that the differences between the price and food production elasticities are accounted for by a combination of episodic emergency needs on the one hand and strong long-term balance of trade desires on the other hand. Because many of the monthly data used were constructed from annual data, no seasonal estimates appear.

Private Domestic Demand: As expected, corn is a substitute for soybeans. The price elasticity between them however appears to be somewhat low but not an order of magnitude error. The most striking results are the futures

Table IV.2 COMPENDIUM OF LONG- AND SHORT-TERM ELASTICITIES IN THE SPOT AND FUTURES MARKET FOR SOYBEANS

Response	Impulse: Net Private Exports	Private Domestic Demand	Private Stocks	Production	Short Hedging	Long Speculation	Near Futures Price	Cash Price	T-Bill Rate	Per Capita Food Prod.:Europe	Per Capita Food Production: Asia	World Price	Shipping Cost	Forecast Revision	Forecast Error Variation	Cash Price of Corn	Cash Price of Soybean Meal	Cash Price of Soybean Oil	Near Futures Price of Corn
Long Term:																			
Net Private Exports	1							-.84		-2.50	-5.01								
Private Domestic Demand		1					1.51	-.40								+.13			
Private Stocks	.72	.34	1	.93				-1.25										+.45	
Production				1			.35	1.14								0		0	
Short Hedging			-.10		1									+.05	.04			+1.71	
Long Speculation						1			-.32					.06	.03			.61	
Near Future Price					0	0	1												
Short Term:																			
Net Private Exports	1																		
Private Domestic Demand		1																	
Private Stocks	.72	.34	1	.93				-2.30										+.60	
Production				1			0	0								0		0	
Short Hedging			-3.30		1									1.70	.10			+1.93	
Long Speculations						1			-1.40					0	-.05			0	
Near Futures Price					-.02	+.02	1												

and cash price elasticities. The cash price elasticity appears somewhat large at -.4 but has the right sign and is within range of cash price elasticities measured by others [34]. 34 The most startling result is the futures price elasticity of +1.51. In addition to being large the sign is difficult to interpret. There is however one explanation that carries some weight: cash commodities may be bought during rising futures prices in anticipation of potential profits from backwardation. In this context the results are in keeping with economic theory. Once again, short-run elasticities are not reported owing to data considerations.

Private Stocks: The elasticities on exports and domestic demand follow from accounting identities and need no special comment here. The fact that private stocks and production don't have an elasticity of one as expected, probably is a result of data inconsistencies. The -1.25 long-run price elasticity is within reason as is the -2.3 short-run price elasticity. The .45 and .68 elasticities with respect to soy oil prices are not hard to accept when one realizes that rising soy oil prices promise higher bean prices and speculative hoarding may take place.

Production: In the long-term both future and cash prices influence production decisions strongly. These results were not paralleled in the short term, however. In part, this inconsistency may be the result of our estimating of production in the aggregate and not estimating acreage and yield separately.

Short Hedging: As hypothesized, stocks play an influential role in hedging with greater impact in the short-run than in the long-run; also as expected. The trend in the near futures price of corn also influences the trend in the supply of futures contracts as one might expect since soy oil and corn oil are substitutes. Most important, the long- and short-run supply of futures contracts appear to be influenced by the accuracy of crop projections.

Long Speculation: Here, the most important factor appears to be monetary conditions i.e. the availability of credit, as reflected in the interest rate on U.S. Government 3-6 month Treasury Bills. In so far as speculators take net financial (as opposed to physical) positions this result is not surprising. What is surprising is the size of the response in the long-run, -.73. Its absence in the short-run is not disturbing owing to the technical rigidities in coordinating short-term futures trading and short-term money market activity.

Near Futures Price: The elasticities reported here stem from the hypothesized relationship between net effective open interest and the change in the near futures prices. The results suggest that the near futures price moved slightly in response to imbalances between supply and demand and obversely that small movements in prices elicit large movements in supply and demand.

2. Wheat

a. Institutional Overview

The Chicago Board of Trade accounts for over

85% of the trading activity in wheat contracts. A contract consists of 5000 bushels and the contract months are July, September, December, March, and May. Wheat is harvested from June to September and the most heavily traded contract is May. Prices are quoted in cents per bushel. The smallest recorded price movement is 1/8 cent or $6.25 a contract. The largest admissible daily price fluctuation is 10 cents per bushel or approximately $2.20 per bushel per month.

The Government plays a strong role in the market for wheat. Most of the carryover from year to year is owned by the Commodity Credit Corporation, an agency of the Department of Agriculture. The loan rate given to producers by the Government is the level around which prices fluctuate. U.S. exports of wheat are made primarily by the Government, since Government wheat price supports tend to be substantially above world market prices.

Unlike soybeans, that are largely transformed into oil and meal, the largest source of domestic disappearance of wheat is food consumption and, therefore, the prices of transformed wheat products such as bread will be reflected in wheat prices.

One of the most important "substitutes" for wheat is corn and a favorite vehicle for speculators has been the spread between long December wheat and short December corn. Corn and wheat harvests are approximately 3 months out of phase, with wheat preceding corn. Accordingly, one can expect to see three month corn futures influencing spot wheat prices. Other less important complements and substitutes include oats and rye. These commodities are not considered here.

b. The Model

The core of the wheat model consists of eight behavioral equations. These equations are presented in Table IV.3 and, like the soybean model in Table IV.1, are in linear semi-reduced form. The structural dialogue between the spot and futures markets is similar to that discussed in the soybean model and need not be repeated here. Similarly, the data transformations also are the same for the wheat model as for the soybean model. It should be noted, however, that the length and timing of the distributed lags in the wheat model should be quite different from those in the soybean market since the harvests are out of phase with one another and are of different lengths. Thus, for example, the impact of USDA forecasts can be expected to exert a different pattern of influence on wheat prices than on soybean prices.

c. The Data

For the most part, the data used in the wheat model required the same type of data transformations and are subject to the same shortcomings as in the soybean model. Accordingly, these procedures are not repeated here. However, there are some exceptions worth noting. First, the "linking" contract month for wheat was taken to be May, the most heavily traded contract. Secondly, the domestic wheat harvest distribution is spread out over the months from June through September. The corresponding USDA forecasts and their standard

Table IV.3 Principal Semi-Reduced Form Estimating Equations For The Spot and Futures Wheat Market Model

Private Domestic Demand (Spot)	$^{DD}q_t^{(j)}$	$= \sum_{k=0}^{K}\sum_{i=1}^{m} h_{1ik}P_{t-k}^{(i)} + \sum_{k=0}^{K}\sum_{i=1}^{m} h_{2ik}P_{t-k,t+T-k}^{(i)} + \sum_{k=0}^{K}\sum_{i=1}^{n_1} h_{3ik}Z_{it-k} + h_0 + \sum_{k=1}^{K} {}^{DD}q_{t-k}^{(i)}$	(2a)
Domestic Production (Spot)	$^{S}q_{t/Y_t}^{(j)}{}^{(j)}$	$= \sum_{i=1}^{m} f_{2i}\bar{P}_{t-12,t}^{(i)} + \sum_{i=1}^{m} f_{3i}P_{t-12,t-12}^{(i)} + \sum_{i=1}^{m} f_{4i}P_t^{(i)} + \sum_{0}^{m}(1-\gamma)_i\, {}^{S}q_{t-12/Y_{t-12}}^{(i)}{}^{(i)} + f_0$	(14)
Net Export Demand (Spot)	$^{DX}q_t^{(j)}$	$= \sum_{k=0}^{K}\sum_{i=1}^{m} g_{1ik}\left(P_{t-k}^{(i)} - P_{t-k}^{W(i)}\right) + \sum_{k=0}^{K}\sum_{i=1}^{m} g_{2ik}\left(P_{t-k,t+T-k}^{(i)} - P_{t-k,t+T-k}^{W(i)}\right) + \sum_{k=0}^{K}\sum_{i=1}^{m} g_{3ik}\,\pi_{t-k}^{(i)} + \sum_{k=0}^{K}\sum_{i=1}^{m} g_{4ik}\,\pi_{t-k}^{(i)} + \sum_{k=0}^{K} D^{X}q_t^{(i)} + g_0$	(3)
Domestic Private Stocks (Spot)	$^{D}S_t^{(j)}$	$= \sum_{i=1}^{m} s_{1i}P_t^{(i)} + \sum_{i=1}^{m} s_{2i}\bar{P}_{t,t+T}^{(i)} + \sum_{i=1}^{m}(1-\gamma)_i\, {}^{D}S_{t-1}^{(i)} + s_0$	(10)
Equilibrium Price (Spot)	$P_t^{(j)}$	$= \sum_{k=0}^{K}\sum_{i=1}^{m} \rho_{3i\,k}\bar{P}_{t-12-k,t-12}^{(i)} + \sum_{k=0}^{K}\sum_{i=1}^{m} \rho_{4i\,k}P_{t-12-k,t-12-k}^{(i)} + \sum_{k=1} \rho_{t-12}^{(i)}\ \sum_{k=0}^{K}\rho_{5k}\, {}^{DX}q_{t-k} + \sum_{k=0}^{K}\rho_{6k}\, {}^{DD}q_{t-k} + \sum_{k=0}^{K}\sum_{i=1}^{n}\rho_{7ik}Z_{it-k} + \sum_{k=0}^{K}\sum_{i=1}^{m}\rho_{8ik}\left({}^{S}q_{t-12-k}^{(i)}, Y_{t-12-k}^{(i)}\right) + \sum_{k=0}^{K}\rho_{9ik}\, {}^{D}S_{t-k}^{(i)} + \rho_0$	(2a. 14. 10. 3. 16)
Demand Effective (Futures)	$^{D}q_{t,t+T}^{(j)}$	$= \sum_{i=1}^{m}\sum_{k=0}^{K} q_{1ki}P_{t-k,t+T}^{(i)} + \sum_{i=1}^{m}\sum_{k=0}^{K} q_{2ki}\sigma_{ki} + \sum_{i=1}^{m}\sum_{k=0}^{K} q_{3i}r_{t-k}^{(i)} + \sum_{k=1}^{K} {}^{D}q_{t,t+T-k}$	(22. 25)
Supply Effective (Futures)	$^{S}q_{t,t+T}^{(j)}$	$= \underbrace{\sum_{i=1}^{m}\sum_{k=0}^{K} q_{4ki}P_{t-k,t+T}^{(i)}}_{\text{net effective}} + \underbrace{\sum_{i=1}^{m}\sum_{k=0}^{K} q_{5ki}\sigma_{ki}}_{\text{not effective}} + \sum_{i=1}^{m}\sum_{k=0}^{K} q_{6ki}S_{t-k}^{(i)} + \sum_{k=1}^{K} {}^{S}q_{t-k,t+T-k}$	(23. 25)
Price Adjustment (Futures)	$\Delta P_{t,t+T}^{(j)}$	$= \sum_{k=0}^{K}\gamma_{1k}^{(j)}\left({}^{D}q_{t+k,t+T-k}^{(j)} - {}^{S}q_{t-k,t+T-k}^{(j)}\right) + \sum_{k=0}^{K'}\gamma_{2k}^{(j)} - \sum_{k=0}^{K}\gamma_{1k}^{(j)}\left({}^{D}q_{t+k,t+T-k}^{(j)} - {}^{S}q_{t-k,t+T-k}^{(j)}\right) + \sum_{k=1}^{K}\Delta P_{t-k,t+T-k}^{(j)}$	(24)

errors are in June, July, August, September and October. The October "forecast", like the November soybean "forecast" occurs after the harvest owing to reporting delays.

The data sources used for the wheat model, for the most part, are the same as those listed for the soybean model. The major additions to these sources include:

- Wheat Situation Report[90]. This source is one of the most complete data libraries for the grain markets in general. Included in its lists are weekly price changes, CCC sales, domestic stocks, exports, and crop forecasts.
- The Grain Market News [85]. This source provides both weekly and monthly summaries of the week's markets, exports of wheat and flour, and government activity and U.S. prospective plantings.
- The Quarterly Stock of Grain in All Positions Report[88]. This source provides a quarterly breakdown of the stocks of wheat by size, location, and ownership.

d. Estimation Results

The emperical results for the wheat model also are encouraging. As in the case for soybeans, the trend equations explained over .90 per cent of the variation and the residuals from these estimating equations do not exhibit statistically significant serial correlation. The auto- and cross-spectral analyses of the estimation residuals did not reveal significant power concentrations at the 20% level and the Durbin-Watson "d" statistics lie between 1.89 and 2.08.

The "seasonal" estimating equations explain between 45 per cent and 80 per cent of the variation. Although the R^2 are lower for the seasonal equations than for the trend equations it must be noted that the seasonal components contain a majority of the noise in the original series. Unlike the other estimating equations in the soybean and wheat models the seasonal equations in the wheat model did exhibit some statistically significant positive auto-correlation. In particular, the production equation had a "d" statistic of 1.43 and a significant power concentration in the 60 to 84 month spectral band. Although the estimating equation did not capture this source of variation the residuals are uncorrelated with the other series of residuals and the total trend plus seasonal variation explained exceeds 85 per cent.

In Table IV.4 we present the major statistically significant impulse-response elasticities estimated in the wheat model. As in the soybean model the elasticities represent the full impact of an impulse on the indicated response variable i.e. they reflect the net impact of the impulse over time.

The results do not contain any major surprises and conform closely to what one would expect. However, each of the relationships warrants some further comment.

Net Private Exports: The most influential factor in long-term net private wheat exports appears to be European per capita food production. This result, of course, corresponds with the dominant U.S. wheat flow to Europe. The price elasticity of -1.47 appears high but of the correct sign.

Table IV.4 COMPENDIUM OF LONG- AND SHORT-TERM ELASTICITIES IN THE SPOT AND FUTURES MARKET FOR WHEAT

Response	Impulse: Net Private Exports	Private Domestic Demand	Private Stocks	Production	Short Hedging	Long Speculation	Near Futures Price	Cash Price	T-Bill Rate	Per Capita Food Prod.: Europe	Per Capita Food Production: Asia	World Price	Shipping Cost	Forecast Revision	Forecast Error Variation	Cash Price of Corn	Cash Price of Soybean Meal	Cash Price of Soybean Oil	Near Futures Price of Corn
Long Term:																			
Net Private Exports	1							-1.47		-3.72		.4							
Private Domestic Demand		1					+.96	-.46								0			0
Private Stocks	.14	.09	1	.90			-.60	.39								-.32			
Production				1			.31	.32								0			0
Short Hedging			1.93		1									0	+.37				.40
Long Speculation						1			-.73					0	-0	0			0
Near Future Price					-.01	+.01	1												
Short Term:																			
Net Private Exports	1																		
Private Domestic Demand		1																	
Private Stocks	.14	.89	1	.90			-3.36	1.93								-1.56			
Production				1			.31	.32											
Short Hedging			2.05		1									0	.14	0			0
Long Speculations						1			0					0	0	0			0
Near Futures Price					-.06	+.06	1												

Similarly, the .4 elasticity on the world price representing Canada, Argentina, and Australia appears to be high but of the correct sign. It must be remembered however that these are private exports and that U.S. Government exports made up the vast majority of U.S. exports over 1961-1971. Owing to the absence of quarterly or monthly data, no short term elasticities are reported.

<u>Private Domestic Demand</u>: The futures and cash prices appear to exert very strong influences on private domestic demand. The positive sign on the near futures price may reflect processors desires to "buy now and save later". The negative sign on the cash price, of course, is what one would expect. Again owing to the annual nature of the data only long-term associations could be tested properly and reported.

<u>Private Stocks:</u> The responses of private stocks to exports, domestic demand and production follow from accounting identities and need not be discussed further. The negative elasticities on long- and short-term corn price movements underscore the substitutability of corn and wheat. The greater cross elasticity in the short-run also comes as no surprise. The most interesting results are the negative elasticities on the futures price and the positive elasticities on the cash price. In a speculative sense this is opposite to what one would expect under normal conditions. No doubt, these results reflect in part the heavy policy actions of the U.S. Government in the wheat market.

Production: U.S. wheat production appears to respond strongly to movements in cash and futures prices. The positive association of course is the only one that makes sensse. The magnitude however is high and again may be the result of Government price stabilization policies. No distinction was made between the long- and short-run here owing to the psuedo periodic and non-stationary character of production.

Short Hedging: The supply of futures contracts does respond strongly to the accuracy of crop forecasts especially in the long run. One would expect just the opposite intensities but, the wheat harvest covers many months unlike soybeans and this physical fact may account for the results. The most distrubing result is the negative association to stocks. However, these results also may be a reflection of hedgers' responses to Government purchases or sales.

Long Speculation: Here, as in the market for soybeans, money market conditions, as reflected in the trend in Treasury Bill rates, are the dominant influence. As noted earlier this corresponds to the predominantly financial character of speculators.

Near Future Price: The response of long- and short-term near futures prices to hedging and speculating is very shallow i.e. moderate changes in near futures prices coincide with very large changes in the quantities of future contracts exchanging hands.

3. General Conclusions

There are a number of important conclusions to be drawn from these case studies. They are:

- The general structure of the spot and futures markets for agricultural commodities are very similar as indicated by the elasticities presented in Tables IV.2 and IV.4. That is not to say that the impulse response relationships are identical but rather that the structural linkages are similar as hypothesized.
- The accuracy of crop forecasts, as measured by their error variation, exert a statistically significant influence on the futures market in both the long- and short-run.
- Hedging activity is closely related to physical stocks of agricultural commodities.
- Movements in cash or spot prices are closely related to movements in physical supplies.
- Net private exports are highly responsive to U.S. prices and per capita foreign food production.
- Domestic private demands for wheat and soybeans are responsive to the spot prices for those commodities.
- Production of soybeans and wheat is responsive to both cash and futures prices.

- Regular seasonal patterns exist in the futures markets for soybeans and wheat.

From these conclusions a few important inferences can be drawn concerning the importance of exports and crop forecast information on the markets for soybeans and wheat. They are:

- Crop forecast error variation (a measure of inaccuracy) is positively related to commodity prices. That is, the higher the forecast error variation the higher the price and obversely the more accurate the forecasts the lower the price.
- Large unexpected surges in foreign demand will have a pronounced effect on domestic prices. Furthermore, these unexpected surges may be viewed as inaccurate forecasts on the demand side. To the extent that these surges in demand result from unexpected harvest results in foreign countries, they may be viewed as inaccurate foreign crop production forecasts.
- From the above inference it follows directly that the accuracy of both domestic and foreign crop production forecasts are an important influence on domestic U.S. commodities markets.

These conclusions have strong implications toward the benefits that may be derived from ERTS crop forecast information and U.S. Government agricultural policies. These topics are the subject of the following section.

V. POLICY COORDINATION AND THE VALUE OF ERS INFORMATION

In this section we discuss the value of ERS information and its role in coordinating U.S. Government agricultural policy. The material is presented in two parts. In Part A we present the rationale for ERS benefits to society, a methodology for estimating those benefits and preliminary estimates of those benefits based on the results presented in Section IV of this study. In Part B we discuss the potential uses of ERS crop forecasts in coordinating U.S. Government agricultural policies. In particular, the discussion focuses on the role of ERS information in the Governments domestic purchases, sales and exports of agricultural commodities.

A. The Value of ERS Information

The only physical products of a space-based ERS system are hard copy photographic prints, computer compatible digital tapes, and data collected by earth-based data collection platforms (DCPs) which are relayed to ground stations by space-based data collection systems (DCS). These products have little economic value aside from those associated with the interesting pictures that one might but to hang on a wall. The economic value of an ERS system derives from the economic value of the information it produces. The value of this information is reviewed here.

1. Rationale for Benefits

Estimates of crop acreage and yields, leading to forecasts of total production levels, are essential for efficient planning in all phases of product processing and distribution. Accurate forecasts permit precise planning for more efficient transportation and processing of commodities, and can help identify potential shortages. Reliable final yield and acreage estimates provide the information necessary for optimal capital investment by processors, and allow estimates of future demands for farm machinery and services.

The forecast of agricultural production is an activity of major importance in the management of natural resources and it is practiced in virtually all countries of the world. The reasons for social benefits accruing to improved crop forecast accuracy are straight forward.

- Inaccurate forecasts result in distorted prices that in turn cause a net decrease in social welfare.
- Timely and accurate forecasts of surpluses or shortfalls allow Governments and private operators to plan domestic and foreign policies and actions: e.g., increased output, reduced costs, remedial action against declining prices.
- Accurate forecasts allow Governments and private operators to optimize the utilization of existing storage, transportation, processing infra-structures and facilities.

For example, consider a simple example pertaining to the production of wheat. A farmer, having raised a marginal winter wheat crop and in the presence of a forecast for a record wheat harvest, might choose not to harvest his wheat, but plow it under for a summer crop. The wheat crop forecast of a record wheat harvest served to reduce the market price structure (the set of present and future prices) of wheat since increased supply interacting with unchanged demand will depress prices. From the farmer's viewpoint, his expected profits (revenues, which depend upon the likely market price minus his costs) are close to zero, or negative, and his correct decision is not to harvest or to plow under most of it. If updated ERTS information (having the attributes of being more timely and accurate than samples drawn by conventional means) indicating a reduced wheat harvest had been available earlier, the farmer might instead have chosen to harvest more of his wheat.

Although the rationale for benefits are straightforward the valuation of these benefits is not intuitively obvious. This issue is discussed next.

2. A Methodology for Valuation

The value of information can be determined using standard economic theory of supply and demand. Figure V.1 presents a typical demand curve for a commodity. Each consumer is faced with a budget constraint which places a limit upon the amount of goods and services that he can command (buy in the market) at any given time. The consumer, therefore, views

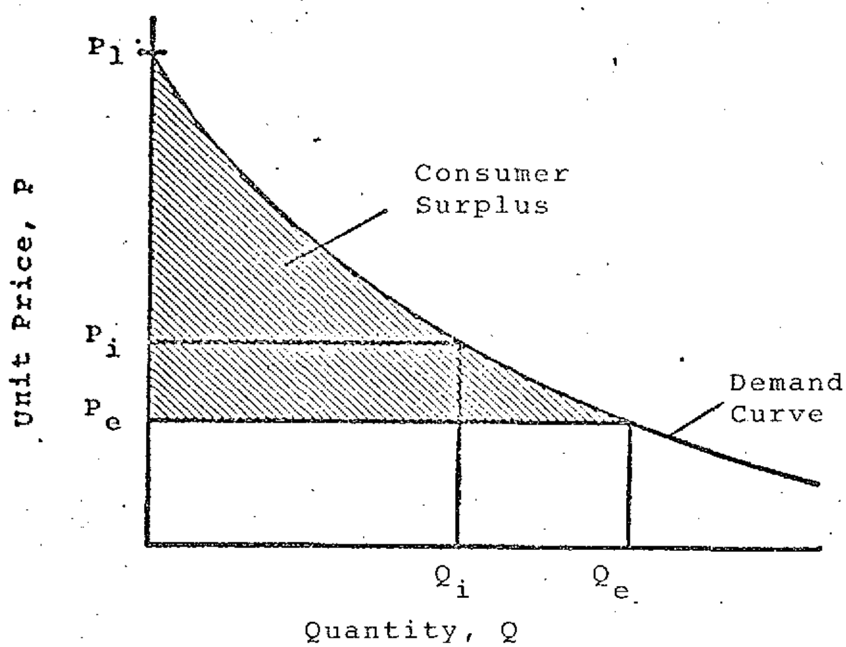


Figure V.1 Consumer Surplus

his consumption of any given commodity as a decision to forego other alternatives that are available to him. Hence, the economic concept of "opportunity cost," that is, the economic cost of an action is what is foregone as its consequence. Anything that can reduce the opportunity costs of actions (decisions) indeed provides economic benefits, and, as shall be shown, this is precisely the role that information plays and the means by which it obtains its economic value. In the same example of the farmer, the opportunity cost of plowing-under his field were the net revenues foregone by the action. If, as the example contended, the market price were (owing to a forecast of a large crop) relatively low, then the opportunity costs, of the plowing-under decision would be zero or even negative (i.e., the farmer would lose money if he decided to harvest). But, as the example went on to show, the actual state of the world was not a bountiful harvest and the market price when the farmer would sell was higher. Thus the realized or ex post opportunity cost of plowing under was positive and the farmer should have harvested and brought the wheat to market. The value to the farmer of the "better" (more timely, more accurate, more complete, etc) information such as the kind that could be obtained from ERS systems, is his net revenue obtained from the change in decision due to the information.

Returning to Figure V.1, theedemand curve illustrates the amount of an item a comsumer will buy at a given price or, obversely the price of consumer will pay for a given quantity. Owing to diminishing marginal utility the consumer may be willing to pay price P_1 for the first unit consumed but pay only price P_i for the i^{th} united consumed. Assuming money is a firm measuring rod of utility, the existing market price is P_e, and consumption is Q_e then the shaded area below the demand curve continuum and above the market price depicts the <u>surplus value</u> received by the consumer by paying price P_e on all Q_e units. The full money value to the consumer is the entire area under the demand curve up to the quantity purchased. The cost to the consumer however is only P_eQ_e. The difference between the full money value and the amount paid is the surplus.

If the market equilibrium price and quantity were P_1 and Q_1 respectively and shifted to P_2 and Q_2 as shown in Figure V.2, consumers would reap the <u>"benefit" or incremental consumer surplus</u> indicated by the shaded area. The area defined by $(P_1 - P_2)\ Q_1$ is called the <u>direct consumer benefit</u> and measures the incremental surplus to consumers if no additional units were purchased in spite of the lowered price. The shaded area corresponding rougly to $1/2\ (P_1 - P_2)\ (Q_2 - Q_1)$ is called the <u>indirect benefit</u> and represents the incremental surplus to consumers from additional purchase owing to the more attractive price.

The above disussion applies only to consumer benefits. Producers' and society's benefit may be illustrated in a similar fashion. In Figure V.3,DD is the aggregate demand function for a

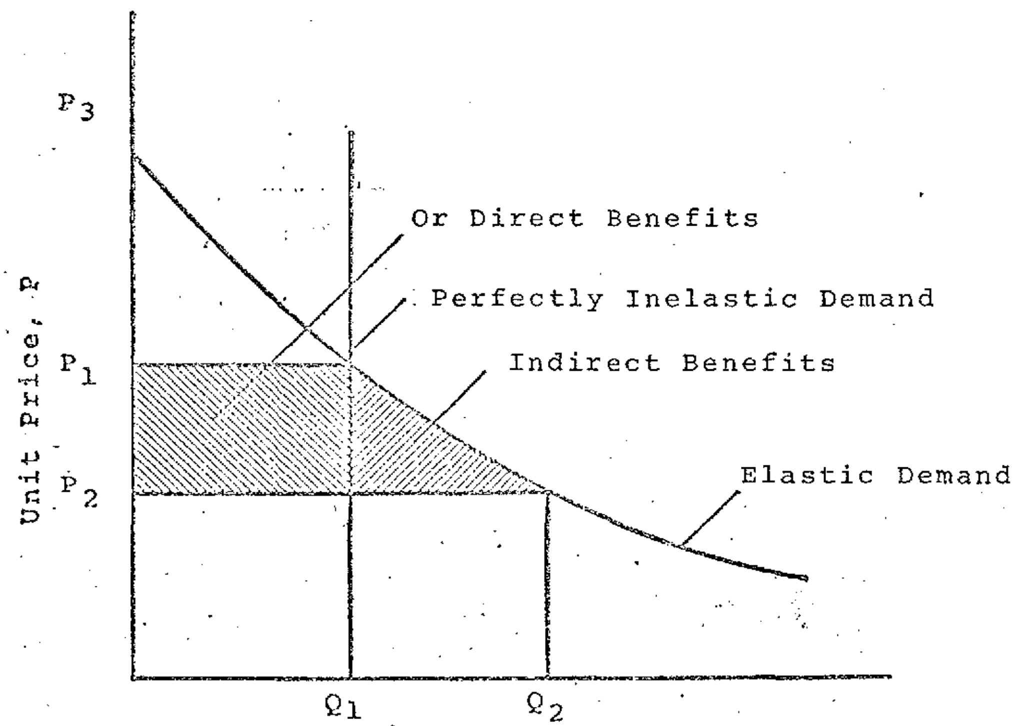


Figure V.2 Incremental Consumer Benefits commodity and the initial market supply-demand equilbrium is such that Q_1 is demanded at price P_1. At the point (P_1, Q_1) the following conditions prevail: consumers are enjoying a net benefit (or consumer surplus) of A, and producers are enjoying a net benefit of B + E, the so-called producer surplus. This latter surplus is the difference between total revenues obtained from selling Q_1 at price P_1 and the cost of producing those items represented by the area below the supply curve and above the horizontal axis between O and Q_1.

Now suppose the supply function shifts from S_1 to S_2, indicating that (in general) each unit of output can be provided at less cost than before. The market will move to a new equilibrium situation and the following conditions will prevail. Referring to Figure V.3, consumer surplus increases from A to A + B + C + D and producer surplus changes from B + E to E + F.

Certainly the consumer reaps benefits from the lowered prices i.e., A + B + C + D >A. The change in producers' benefits however are not necessarily positive since $B + E \gtrless E + F$. The result depends upon the elasticities of the supply and demand curves. The net benefit to society would be B + C + D + F - B or C + D + F and also depends on the elasticities of supply and demand.

3. <u>Types of Benefits From Improved Crop Forecast Information</u>

With the above concepts as a backdrop there are three major types of benefits from improved crop forecast information: distribution benefits, dishoarding benefits and production benefits. Each of these benefits is described further in the following paragraphs.

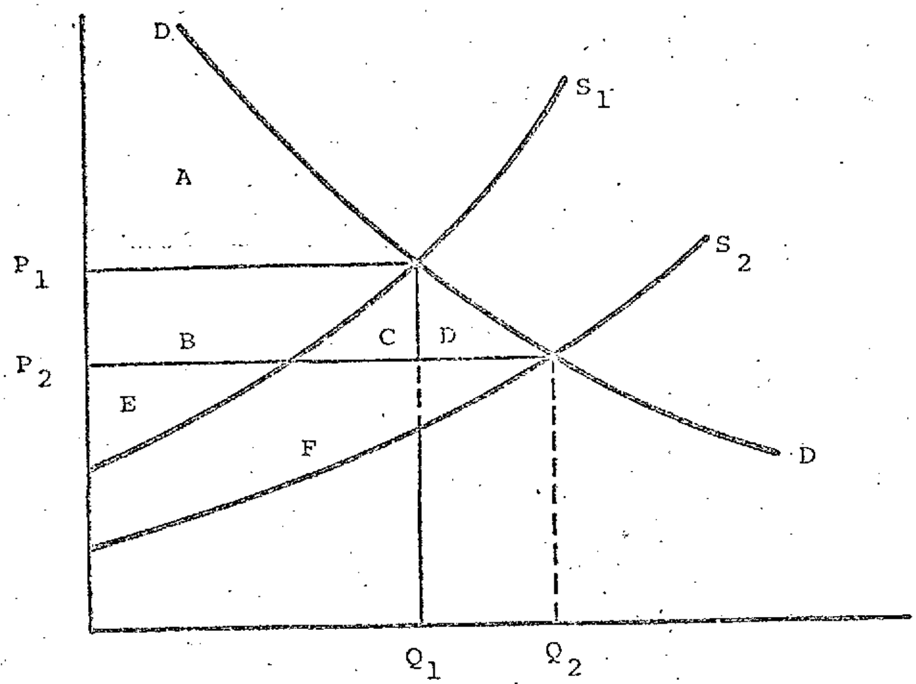


Figure V.3 Increments in Consumer and Producer Surplus

a. Distribution Benefits

"Distribution benefits" arise when a given (perfectly inelastic) supply of some commodity is consumed fully in a two period world that responds to imperfect forecasts as if they were true. These benefits are illustrated in Figures V.4(a)(b)(c) and (d). In the upper left-hand chart, (a), the true supply and demand for a commodity are presented. Here the equilibrium price and quantity are P_o and Q_o, respectively. Now, suppose that in period 1, supply is believed to be Q_1 and the market quilabrates at price P_1. This is shown in the upper right hand chart of Figure V.4. Here the shaded area indicates the period 1 welfare loss, owing to the underestimate of supply. By the next period, however, the underestimate of supply has been detected and the supply of the commodity surges to an "effective two period level" of Q_2 with a new lower price of P_2. This reaction is shown in chart (c) in the lower left-hand corner of Figure V.4. Here the shaded area indicates the welfare gain in the second period. Without regard to discounts, etc. the net welfare loss to society owing to misinformation is the shaded area in chart (d) in the lower right-hand corner of Figure V.4.

In this admittedly simple world, the net welfare loss indicates the potential welfare gain to society from perfect information at the outset. A partial improvement in information, of course, will capture only a portion of the original welfare loss or potential welfare gain. This partial improvement is

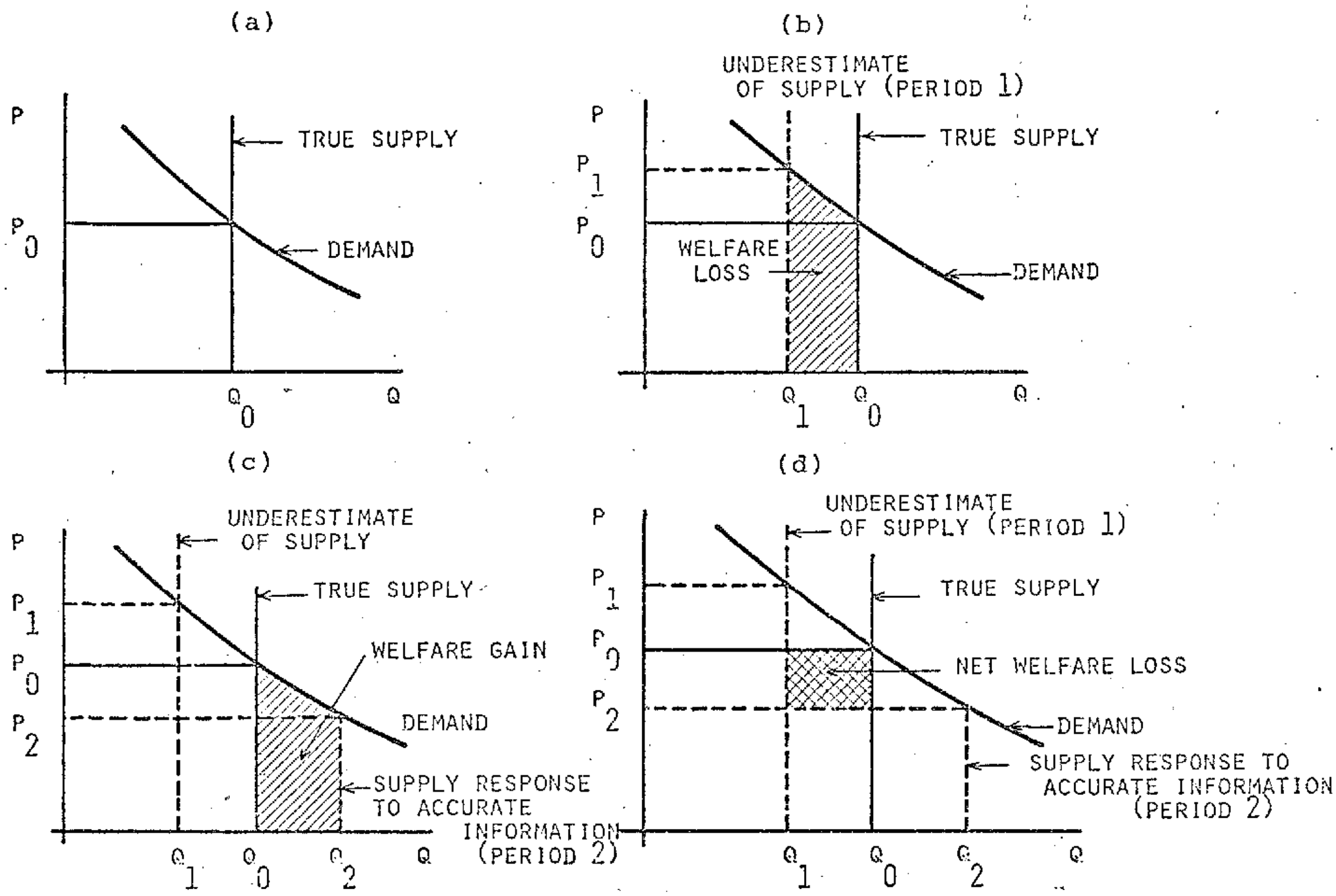


Figure V.4 Potential Distribution Benefits is illustrated in Figure V.5. In this figure the original welfare loss or potential welfare gain, is the shaded area bounded by P_o, P_2, Q_1 and Q_o. This loss, of course, corresponds to some original forecast error probability density function. Improved information, is reflected in a narrower or tighter forecast error distribution. The reduction in forecast error variation implies a new and smaller welfare loss (the Residual Welfare Loss) bounded by P_o, P_2*, Q_1*, and Q_o. The difference between the original welfare loss and the residual welfare loss is the welfare gain owing to improved information and is illustrated in the lower right of Figure V.5.

An estimate of this type of benefit is extremely complex and involves the use of simulation methods owing to the stochastic nature of the problem, the possibility of carry over and the variable lengths of the storage and distribution periods. A more detailed discussion of these benefits, and their measurement, is presented in another ECON cast study* and are not repeated here.

b. Dishoarding and Production Benefits

Dishoarding benefits arise in a world that is risk averse and tempers its response to forecasts owing to their uncertainty. Here, stocks are assumed to be hoarded in proportion to the uncertainty surrounding anticipated or forecasted harvests.

---

* Bradford, D. and Kalegin, H., The Value of Improved (ERS) Information based on Domestic Distribution Effects of U.S. Agricultural Crops, ECON, Inc., Princeton, N.J., 1974 (forthcoming)

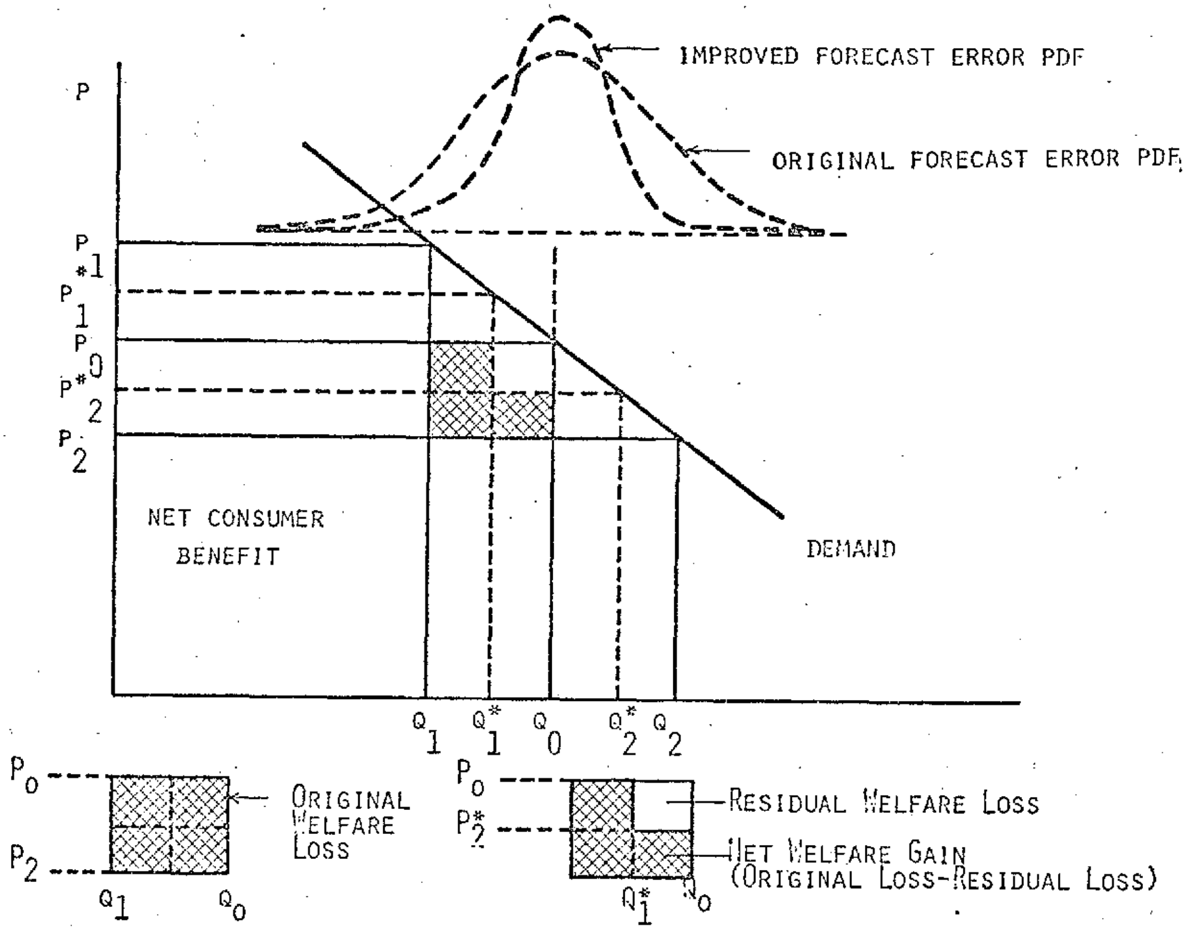


Figure V.5 Distribution Benefits From a Partial Improvement in Information.

Improved forecasts in this case would reduce uncertainty and therefore reduce risk balances and their associated storage costs and increase available stocks. The reduced storage costs and increased availability of stocks would be reflected by an increase in supply, as illustrated in Figure V.6. The benefits to consumers, producers and society from the increased supply are indicated in Figure V.6 and the corresponding algebraic summary.

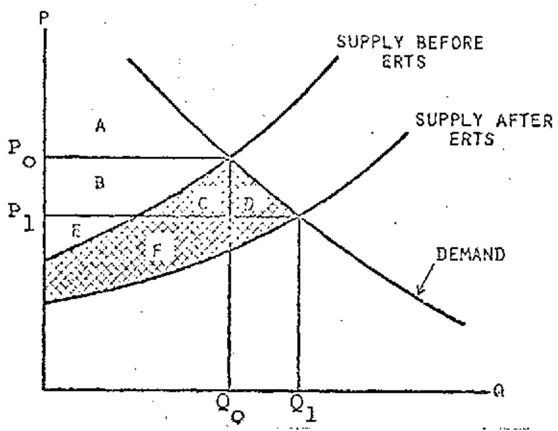
Production benefits manifest themselves in a manner similar to the dishoarding benefits discussed above. In this case farmers may pass on lower production costs owing in part to reduced storage costs for "risk balances" of feed, seed and other factors of production. Lower production costs again may be illustrated as an increase in supply. This increase in supply and the resulting benefits to consumers, producers and society are illustrated in Figure V.7.

Before turning to our estimates of ERTS benefits (Type II or dishoarding benefits) it is worth noting the various technical attributes of a crop forecasting system and our focus on improved forecast accuracy in assessing the value of dishoarding benefits.

4. <u>The Characteristics of Improved Crop Forecast Information</u>

A crop forecast system can be described by technical attributes. These attributes include: timeliness, accuracy, completeness, and dependability.

<u>Timeliness</u> is a term for the attribute of the system which reduces the lage between the occurrences of a phenomenon and the

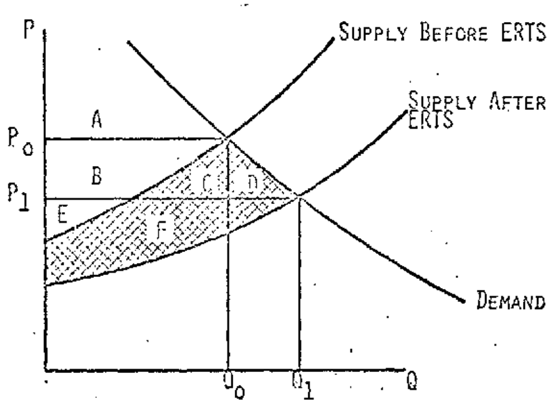


INCREMENTAL CONSUMER SURPLUS
B + C + D

INCREMENTAL NET PRODUCERS SURPLUS
E + F - (B + E) = F - B

NET WELFARE GAIN
C + D + F

Figure V.6 Dishoarding Benefits



INCREMENTAL CONSUMER SURPLUS
B+C+D

INCREMENTAL NET PRODUCER SURPLUS
E+F-(B+E) = F-B

NET WELFARE GAIN
C+D+F

Figure V.7 Protection Benefits

knowledge of the event by decision-makers who may benefit from the information. With the current capability of one-in-eighteen day observation of the same area and the future possibility of "real time" observation (using synchronous satellites), the decision-maker can react with minimum delay to natural and man-made events. "Time" is certainly one of the most important elements in production in modern economy, and any system that can reduce this factor will provide economic benefits.

Accuracy relates to the ability to correctly interpret the system's information (ERTS imagery). This places a burden on the system to provide relevant data that can be interpreted accurately. There are technical properties of ERS imagery that strongly suggest the system will record events more accurately than by conventional means. A satellite system provides sun synchronous imagery of the same area, it does not require orthographic rectification, and it can take "snapshots" of large area phenomenon. The corresponding forecast improvements over current methods are presented in Part 5 below.

Completeness expresses the attribute of effective sample size. It would, from a cost standpoint - assuming that the other technical attributes were attainable by other means - be prohibitive to acquire the same amount of information made available by ERTS from some other existing crop monitoring system.

Dependability refers to the attribute of regular and repetitive coverage. For ERTS-type systems there is the problem of cloud cover. However, there is a very high probability that anyone seeking an image of a given area will obtain it over a number of satellite passes. Of coursé, a user may want the information for a given day, week, month, season, etc; and cloud cover can inpurge on this demand for timeliness. But inclement weather conditions hold for aircraft-derived imagery and ground truth as well.

Estimating the benefits from an improvement in each of the above attributes is beyond the range of this study. As a first attempt, our focus here is on improvements in crop production forecast accuracy. As noted in Chapter IV above, accuracy is measured in this study by the average absolute percent errors of annual crop production forecasts made one, two, three, etc. months prior to harvest. In Chapter IV it also was noted that this proxy measure of risk was found to have a significant impact on futures prices and quantities which, in turn, were related to physical prices and quantities. These results make it possible to assess some of the benefits from potential ERTS improvements in forecasts. These estimates are discussed further in the following paragraphs.

5. <u>The Value of Improved Information: The ERTS System</u>

In the following paragraphs we present our estimates of the annual dishoarding benefits to consumers from potential ERTS improvement over current crop forecast accuracy on soybeans and wheat. These estimates are based on likely ERTS accuracy improvements (to be presented), the elasticities presented in Tables IV.2 and IV.4 above and on 1973 prices and quantities. The actual calculation of these benefits, given in part V.A.5.b. below, are illustrated in the flow chart in Figure V.8. Here, an assumed change forecast error variation (a reduction) is traced through the system of elasticities to determine relative price and quantity impacts. These impacts then are combined with 1973 prices and quantities to provide the benefits estimates. It should be noted that conservative upper and lower bounds are given. The "uper bound" indicates the direct benefits to consumers using the estimated coefficients. The lower bound represents an estimate of the direct benefits to consumers where the "slope" portion of the elasticities have been lowered or raised two standard deviations in order to obtain an unlikely low benefits value.

Two additional points must be noted. First, the benefits estimates presented are not based on a full simultaneous solution of the model involving all of the estimated elasticities and interconnections. To be sure such an approach is desirable and, based on our findings in this study, appears to be within reach of an extended and expanded effort. This time around, however, we must limit ourselves to the "conditional" benefits estimates presented.

Second, as noted above, the size of the benefits from improved information depend in part on the assumed improvements

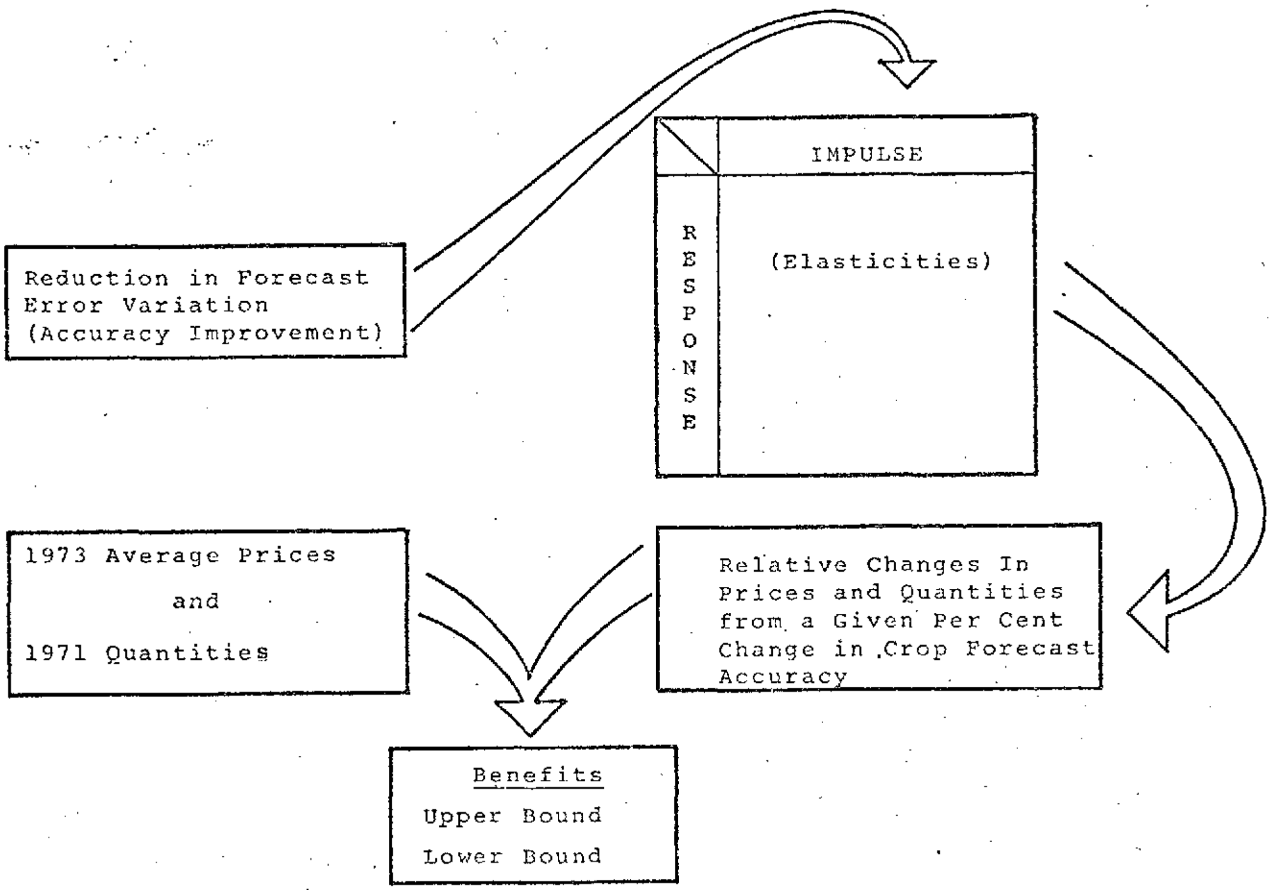


Figure V.8 The Calculation of Benefits

in forecast accuracy. Outrageous assumptions as to accuracy improvements, of course, would invalidate the benefit figures. The improvements assumed here are thought to be conservative and are discussed further below.

a. Likely Accuracy Improvements from an ERS System

An analysis of the accuracy of crop forecasts by Gunnelson et al* concludes that the USDA tends to (1) under-estimate crop size, (2) under-estimate the size of changes in production from year-earlier levels and (3) undercompensates for error in previous forecasts when developing revised crop forecasts. Absolute forecasting errors are a function of the length of the forecasting period. Examples of average fore-casting errors by month of forecast for various commodities are presented in Table V.1 below.

Crop production estimates are generally arrived at as the product of two components: acreage and yield per acre. Approximately one-half of the inaccuracy of U.S. wheat and soy-bean production forecasts is in the estimation of the acreage component. Thus, even if remote sensing could improve only the acreage portion of the reduction estimate, a significant improve-ment in the production forecast would result. Based on the Task

* Gunnelson, G. et al, "Analysis of the Accuracy of USDA Crop Forecasts," American Journal of Agricultural Economics, Vol. 54, No. 4, Part 1, November 1972: pp. 693-645.

Table V.1 Size of Average Absolute Percentage Forecasting Error in USDA Crop Forecasts by Commodity and Forecast Month, 1929-1970[a]

	Absolute Error by Forecast Month (Percentages)								
Commodity	December	April	May	June	July	August	September	October	November
Barley					7.1	3.1	2.2		
Corn					9.2	5.9	4.0	2.8	2.0
Oats					4.9	2.9	2.4		
Potatoes						5.5	4.5	3.2	2.6
Soybeans						5.6[b]	5.1[c]	3.7[c]	2.9[c]
Spring Wheat					10.7	6.7	3.0	2.8	
Winter Wheat[d]	11.5	8.5	7.6	6.9	4.0	2.1			

[a] Forecasting error equals the absolute difference between the forecast and the December revised estimate expressed as a percentage of the December revised estimate.

[b] Percentages computed from data for 1944-1970.

[c] Percentages computed from data for 1940-1970.

[d] Error percentages for December 1-1 winter wheat forecasts computed from data for 1942-1970. Error percentages for other winter wheat forecast months computed from 1929-1970 data.

Source: Gunnelson, G. et al, "Analysis of the Accuracy of USDA Crop Forecasts" American Journal of Agricultural Economics, Vol.54, No.4, Part 1. November 1972. pp. 639-645.

Force on Agricultural Forecasting Report,* current data strongly suggest that ERTS may improve acreage forecasts by at least 50 percent throughout the forecast period [92]. That is, ERTS-based acreage forecasts would have less than half the error variation of current USDA acreage projections. Thus, in the benefits estimates to be presented, the calculations assume only a 25% improvement in production forecast error variation. Since studies of ERTS-1 yield estimates suggest that similar improvements may be made here and since timing, completeness and dependability improvements have not been considered the assumed ERTS improvement in production forecasts are considered to be conservative.

The potential accuracy improvements in ERTS-1 over current USDA methods are shown in Figure V.9. It is on the basis of these data that our ERTS accuracy improvement assumptions were made.

b. Benefits Estimates

The estimated direct benefits to consumers from a 25% reduction in forecast error variation are summarized in Table V.4. These values were calculated using the assumed ERS accuracy improvement together with the elasticities presented in Tables IV.2 and IV.4 and 1973 prices and quantities.

---

* Wood, D.B., et al, "The Use of the Earth Resources Technology Satellite (ERTS) for Crop Production Forecasts," Task Force on Agriculture Forecasting, Goddard Space Flight Center, Draft Final Report, July 24, 1972.

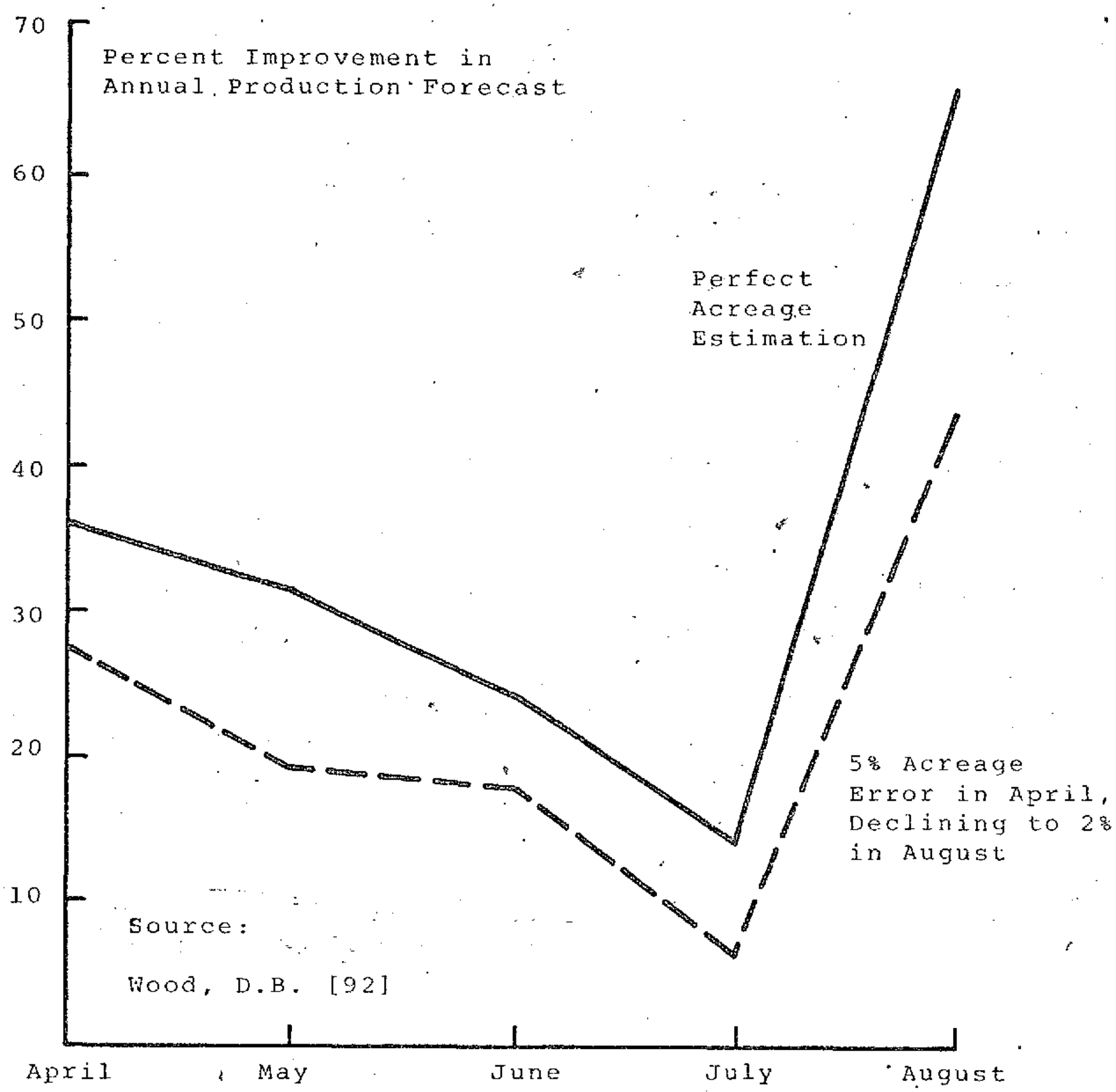


Figure V.9 Illustrative ERTS-1 Accuracy Improvement In Crop Forecasts

The actual calculation of the benefits are set forth in Tables V.2 and V.3. The upper bound benefits value is based on the reported estimation coefficients. The lower bound benefits were calculated using impulse response coefficients two standard deviations below (or above) their estimated value. In a statistical sense it is highly unlikely that the consumer benefits from a 25% reduction in crop forecast error variation will fall below the lower bound benefits values. Moreover it is worth noting that these benefit estimates are especially conservative in so far as they only reflect the direct benefits to consumers and do not include the likely yield estimate improvements and secondary effects such as those brought about by the increased availability of loanable funds.

B. Government Agricultural Policy Action and the Impact of Improved Crop Projections.

In the previous paragraphs estimated benefits to society of ERS crop forecast information were presented. In these paragraphs the operational side of these ERS benefits are explored specifically the discussion focuses on the impact of ERS crop projections on the government's policy operations in markets for agriculture commodities. It must be noted that no attempt is made here to assess the "right" or efficiency of the government's activity in the domestic and foreign markets for commodities. Rather the discussion here is positive and describes the likely impact of ERS crop forecast information on government's policy operations regardless of the merit of those objectives. To be sure, it is beyond the scope of this discussion to explore this

Table V.2 Direct Consumer Benefits Estimates for Soybeans

Upper Bound

$$U_s = \begin{pmatrix}\text{\% Change in Fore-}\\ \text{cast Error Variations}\\ .25\end{pmatrix} \begin{pmatrix}\text{Accuracy Elasticity}\\ \text{of Short Hedging}\\ .038\end{pmatrix} \begin{pmatrix}\text{Hedging Elasticity}\\ \text{of Private Stocks}\\ 1/.184\end{pmatrix} \begin{pmatrix}\text{\% Change in Spot Price}\\ \text{from a 1\% Change in}\\ \text{Quantity } \frac{1}{1.280}\end{pmatrix} \begin{pmatrix}\text{1973}\\ \text{Price}\\ \$6.52\end{pmatrix} \begin{pmatrix}\text{1973}\\ \text{Quantity}\\ \text{1,283 mill.bu.}\end{pmatrix}$$

$$= \$337 \text{ million}$$

Lower Bound

$$L_s = \begin{pmatrix}\text{\% Change in Fore-}\\ \text{cast Error Variations}\\ .25\end{pmatrix} \begin{pmatrix}\text{Accuracy Elasticity}\\ \text{of Short Hedging}\\ .026\end{pmatrix} \begin{pmatrix}\text{Hedging Elasticity}\\ \text{of Private Stocks}\\ 1/.338\end{pmatrix} \begin{pmatrix}\text{\% Change in Spot Price}\\ \text{from a 1\% Change in}\\ \text{Quantity } \frac{1}{2.262}\end{pmatrix} \begin{pmatrix}\text{1973}\\ \text{Price}\\ \$6.52\end{pmatrix} \begin{pmatrix}\text{1973}\\ \text{Quantity}\\ \text{1,283 mill.bu.}\end{pmatrix}$$

$$= \$71 \text{ million}$$

Table V.3 Direct Consumer Benefits Estimates for Wheat

Upper Bound

$$U_w = \begin{pmatrix}\text{\% Change in Fore-} \\ \text{cast Error Variation} \\ .25\end{pmatrix} \begin{pmatrix}\text{Accuracy Elasticity} \\ \text{of Short Hedging} \\ .365\end{pmatrix} \begin{pmatrix}\text{Hedging Elasticity} \\ \text{of Private Stocks} \\ 1/1.982\end{pmatrix} \begin{pmatrix}\text{\% Change in Price} \\ \text{from a 1\% Change} \\ \text{in Quantity } 1/.394\end{pmatrix} \begin{pmatrix}1973 \\ \text{Price} \\ \$2.31\end{pmatrix} \begin{pmatrix}1973 \\ \text{Quantity} \\ \text{786.6 mil.bu.}\end{pmatrix}$$

$$= \$212 \text{ million}$$

Lower Bound

$$L_w = \begin{pmatrix}\text{\% Change in Fore-} \\ \text{cast Error Variation} \\ .25\end{pmatrix} \begin{pmatrix}\text{Accuracy Elasticity} \\ \text{of Short Hedging} \\ .145\end{pmatrix} \begin{pmatrix}\text{Hedging Elasticity} \\ \text{of Private Stocks} \\ 1/3.422\end{pmatrix} \begin{pmatrix}\text{\% Change in Price} \\ \text{from a 1\% Change} \\ \text{in Quantity } 1/.55\end{pmatrix} \begin{pmatrix}1973 \\ \text{Price} \\ \$2.31\end{pmatrix} \begin{pmatrix}1973 \\ \text{Quantity} \\ \text{786.6 mil.bu.}\end{pmatrix}$$

$$= \$35 \text{ million}$$

Table V.4 Estimates of Annual ERTS Benefits (Based on Likely Reduction in Crop Production Forecast Error Variation as Determined By D. B. Wood [92].

Crop	Annual Benefits	
	Lower Bound	Upper Bound
Soybeans	$ 71 mill	$337 mill
Wheat	$ 35 mill	$212 mill
TOTAL	$106 mill	$549 mill

area in detail. However, strong policy observations can be made from a broad brush stroke portrait of the issure. In the paragraphs to follow two examples are used to sketch such a portrait. Before turning to these examples some description must be given of the government's basic posture in the economy in order to view properly the ERTS impact to be discussed.

It is assumed that the government sets goals or targets on agricultural prices and attempts to achieve those goals through judiciously orchestrated purchases and sales of the "targeted" commodity. Thtat is to say, the government is assumed to act as a grand economic agent to equilibrate supply with demand at some "desired" price. With this backdrop, the discussion now turns to the impact of ERS-improved crop forecast accuracy on the government's domestic and foreign agricultural policy operations.

1. Improved Information and its Impact on Government Domestic Purchases or Sales

A common domestic objective of the government, operating through the CCC, is to ensure a parity price for certain agricultural commodities such as wheat. The basic operating rule for the CCC is to purchase a commodity when the market price threatens to fall below parity and sell the commodity when prices have surged beyond some predetermined upper limit. These actions by the government serve to increase demand in the former case and increase supply in the latter. Ceterus paribus, the results in turn exert upward or downward pressures on prices, respectively.

Market prices, however, also reflect expected demands and expected supplies. Because crop forecasts, and therefore expected supplies, change from month to month as the harvest draws near the government may be buying one month and selling the nest in response to changes in market expectations owing to changes in crop forecasts.

To the extent that forecast errors manifest themselves in spurious price movements, the government will buy and sell the affected commodity to keep its price within bounds. Thus, the government acts to insulate the market from forecast "noise". Obersely if the forecasts wer perfect the government still may enter the market to offset any demand-supply imbalance vis a vis desired prices. ERS information, of course, will not alter these operating rules. The impact of ERS in this context simply will be to reduce the "noise" the government must filter from the system. Thus, ERS-improved forecasts may exert a passive influence on government domestic operations. However, there is one way in which the ERS noise reduction may enhance government policy operations. Every reduction in market noise only improves the government's view of the market and therefore helps the government design and implement better and more efficient agricultural policies.

2. Government Agricultural Export Policies and World Wide Crop Projections

The most recent Russion wheat deal illustrates the importance of a world wide monitoring system and how such a system can assist U.S. agriculture export policies. Although the pictorial history of that transaction in Figure V.5 virtually is self explanatory, some further comment is warrented. In early to mid 1973 the United States opened its wheat supplies to the Soviet Union. At this time it was known that the Soviets would experience a serious shortfall in wheat production. However, the size of the shortfall and the potential purchase was not known to the market. Recognizing the economic value of an uninformed well intentioned trading partner, the Russians moved swiftly and purchased millions of tons of wheat for future delivery at prixes that reflected the market's ignorance. Soon after the massive Russion entry into the market U.S. domestic prices soared to record levels.

In its negotiating with the Soviet Union the United States government expected Soviet purchases of up to 10 million tons. The elasticities presented in Table IV.4 and based on 1960-1971 data suggest that such a massive increase in demand would raise prices by almost 100 per cent. In fact the Soviets contracted for 10 million tons of wheat in less than a month and went on to purchase at least an additional 2 million tons. Had this market impact (of sales of this magnitude) been known by the United States the Russion entry into the market could have been phased over a longer period. In this way the market could have adapted to each Soviet bid and, as prices rose, the Soviet appetite may have been curbed. At the very least, the Soviets would have shared the first operational costs of Detente.

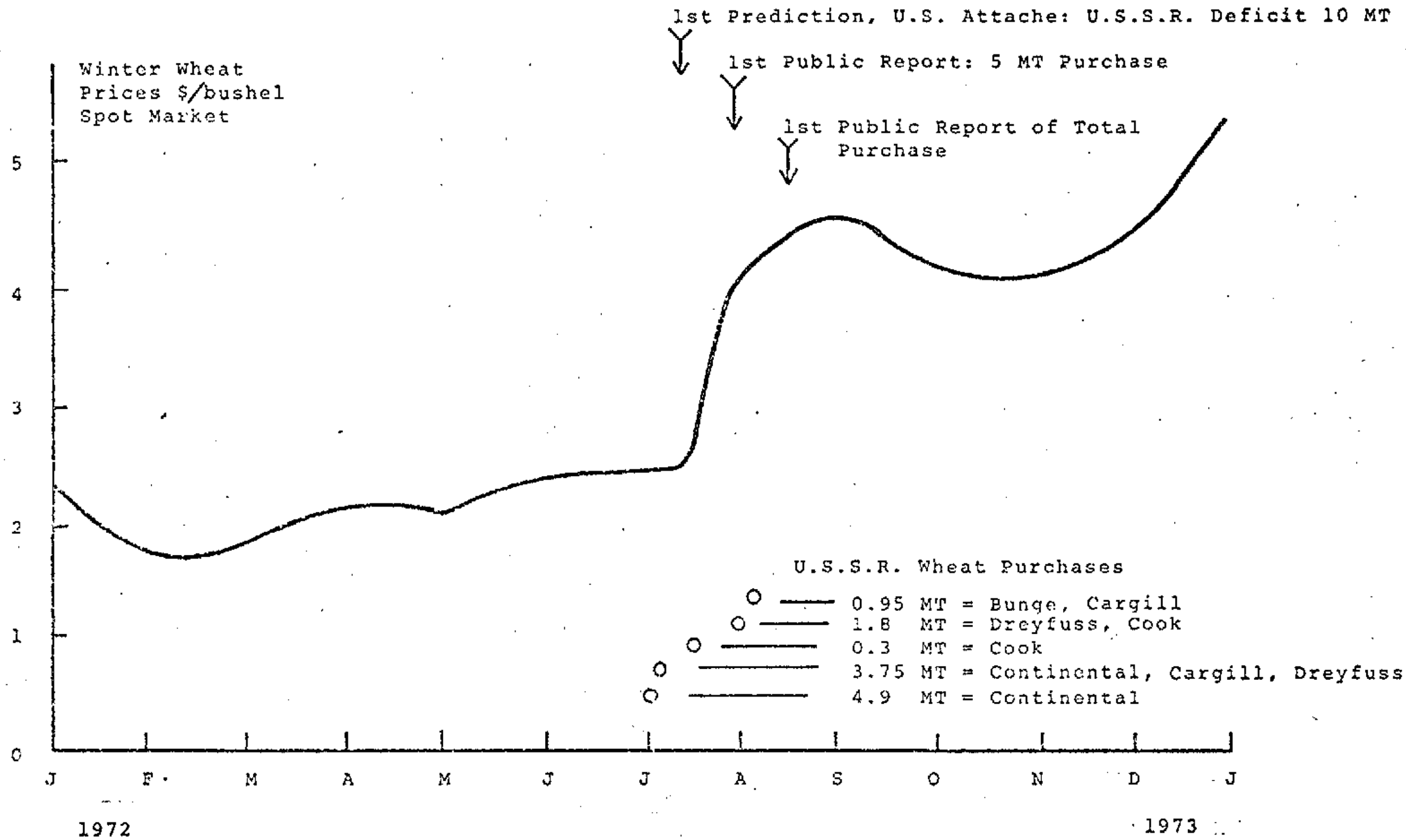


Chart V.10 An Example of the Effect of Uncertain Information

Source: Ecosystems International, Inc.

On the one hand, the new round of inflationary pressures brought on by the Russions wheat deal, could have been reduced through the intelligent scheduling of the Soviet entry into the market by the U.S. trade negotiators. On the other hand, even if the U.S. trade negotiators were not wise to the likely market impact of such a transaction the market was. The problem here, of course, is that the U.S. trade negotiators and the market did not have accurate estimates of Russion demand i.e., we did not have accurate estimates of the shortfall in the Russian harvests. Had this information been available to the market, and the U.S. trade negotiators, the market could have taken a realistic bargaining position. It is claer that ERS information together with knowledge of the market and intelligent bargaining could ahve satisfied Russian demands without full subsidization by the American consumer.

VI. GENERAL CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The purpose of this study was to develop a better understanding of the commodities markets, with special emphasis on the importance of crop forecast information and foreign trade, in order to assess the benefits to society from improved (ERS) crop projections. To achieve these goals it was necessary to determine the elasticities of demand and supply in both the current (spot) and forward (futures) markets for agricultural commodities. This was accomplished through the formal development and estimation of economic relationships describing the behavior of the markets. The model followed the analytical and empirical lead of others and, for the most part parallels earlier findings. The principal unique contribution is the direct testing of the influence of crop forecast accuracy on market behavior. Although the empirical results and policy conclusions have been presented elsewhere, these results warrant repeating here where their full meaning and significance can be appreciated. To be sure this report is not the last word on the complex issues studied and there are many areas where fruitful further research should be conducted. Accordingly in the last paragraphs of this report, the most promising of these areas are set forth.

A. Conclusion

There are several major conclustions to be drawn from this study. They are

- Crop forecast accuracy plays an influential role in the commodities markets.
- Prices of commodities move directly with crop forecast accuracy. That is, increases in forecast inaccuracy lead to higher commodity prices, ceterus paribus and obversely, improvements in crop forecast accuracy lead to lower commodity prices.
- A twenty five per cent improvement in the accuracy of soybean and wheat crop production forecasts, promises tens of millions of dollars worth of benefits to society.
- Improved crop production forecasts will not impinge on U.S. government domestic agricultural policy objectives and operations. In fact, improved crop forecasts will enhance the soundness of those objectives and the precision of these operations.
- Domestic production is very responsive to prices and increases in foreign demand will create upward pressures on prices.
- Foreign demand for U.S. soybean and wheat closely reflects foreign per capita food production

- Improved estimates of foreign food production used wisely by all trading parties can lead to "pareto optimal" exchange where neither party is worse off and at least one party is better off.
- Failure to discriminate, or use wisely, accurate foreign crop production forecasts promises future reenactments of the "pareto suboptimal" wheat transaction between the United States and the Soviet Union.
- Long-term credit availability is an important influence in the commodities markets and is influenced by inflation and the factors influencing the rate of inflation.

There are a number of other specific and technical conclusions to be drawn from this study. They are presented in Sections IV and V and though important to the specialist, need not be re-repeated here. There are, however, a number of important areas where further research and investigation is crucial and these topics are summarized next.

B. Recommendations for Further Research.

The operating thesis of this study was to focus on major issues and robust findings; leaving important but secondary issues for future research. Among the most important of these issues and problems are the following:

- Owing to the interdependencies between crop production decisions and between crop consumption decisions a full complement of agriculture commodities should be studied in detail.
- Because individual crops vary in quality, harvest time and final use, considerable attention should be directed toward these intensive issues to better understand the incidence of societal benefits from an ERS system for each crop.
- Differences in tastes, soil fertility and harvest time all suggest that foreign demand for U.S. agricultural commodities be investigated with much greater detail so as to assess properly the benefits of ERS to all trading partners.
- Further work must be done to improve the quality of the current data used for empirical estimation. Here improved sampling procedures and more complete and

highly resolved records are most important.

- The channels of communication that transmit production forecast data to the market should be studied in detail so as to properly assess the value of timeliness in crop forecast information.
- The competitiveness of the domestic markets for agricultural commodities should be studied in order to identify possible information bottlenecks.

Each of these issues is a major topic in itself and their absence from this study only serves to dilute its potential. Nevertheless, the findings are substantial and argue strongly for the implementation of an ERS system. To be sure, the substantial benefits from ERS may not be realized owing to the unscrupulous acts of those who would restrain trade for private gain or because the information from ERS is not used or disseminated wisely. Ignorance and wanton abuse, of course, are not reasons to refrain from implementing an otherwise beneficial system.

BIBLIOGRAPHY

[1] Aliber, Robert Z. "Speculation and Price Stability Once Again." Journal of Political Economy 72 (1964):607-609

[2] Baer, Julius B., and Saxon, Olin G. Commodity Exchanges and Futures Trading. New York:Harper & Brothers, 1949.

[3] Baumol, W. J. "Speculation, Profitability and Stability." Review of Economics and Statistics, 39 (August, 1957):263-271

[4] Beckmann, M.J. "On the Determination of Prices in Futures Markets." In Patterns of Market Behavior, edited by M. J. Brennan. Providence:1965.

[5] Board of Governors of the Federal Reserve, The Monthly Report of the Federal Reserve System, 1961-1962.

[6] Box, G.E.P. and Jenkins, G. M. Time Series Analysis:forecasting and control, Holden-Day, San Francisco, 1970.

[7] Brennan, M. J. "The Supply of Storage." American Economic Review 40 (March 1958):50-72.

[8] Chicago Board of Trade, The Statistical Annual of the Chicago Board of Trade, (1965, 1968).

[9] Commodity Exchange Authority, Commitments of Trades in Commodity Futures, Chicago, 1961-1972.

[10] Commodity Research Bureau, The Commodity Yearbook, New York 1968-1974.

[11] Cootner, Paul H. "Common Elements in Futures Markets for Commodities and Bonds." Proceedings of the American Economic Association 51 (May 1961):173-183.

[12] Cootner, Paul H. "Returns to Speculators:Telser versus Keynes." Journal of Political Economy 68 (August 1960):397-418; reply by Telser, ibid., pp. 404-415;rejoinder by P. H. Cootner, ibid.,

[13] Cootner, Paul H. "Speculation and Hedging." Food Research Institute Studies 7,supp. (1967):65-106.

[14] Dow, J.C. R. "The Inaccuracy of Expectations." Economica 8 (May 1941).

[15] Dulay, H. "On the Variance Effects of a Buffer-Stock Scheme: A Simulation Study of a Floor Price Plan for Wood." 4 Australian Economic Papers (June-December 1965):79-92.

[16] Ehrich, R. L. "Cash-Futures Price Relationships for Live Beef Cattle." American Journal of Agricultural Economics 51 (February 1969):26-39.

[17] Ehrich, Rollo L. "The Impact of Government Programs on Wheat-Futures Markets, 1953-63." Food Research Institute Studies 6 (1966):313-338.

[18] Fama, E. F.; Fisher, L.; Jensen, M.C.; and Roll, R. "The Adjustment of Stock Prices to New Information." International Economic Review 10 (February 1969):1-21.

[19] Fishman, G. S. "Price Behavior Under Alternative Forms of Price Expectations." Quanterly Journal Of Economics 78 (May 1964):281-298.

[20] Foote, Richard J.; Klein, J. W.; and Clough, M. The Demand and Price Structure for Corn and Total Feed Concentrates. U.S. Department of Agriculture, Technical Bulletin no. 1061. Washington, D.C.:Government Printing Office, October 1965.

[21] Gold, G. Modern Commodity Futures Trading. Commodity Research Bureau Inc., New York, 1959.

[22] Granger, C. W. J. and Hatanaka, M. Spectral Analysis of Economic Time Series. Princeton University Press, Princeton, N.J., 1964.

[23] Gray, Roger W. "The Seasonal Pattern in Wheat Futures Prices under the Loan Program." Food Research Institute Studies 3 (February 1962):23-24.

[24] Gray, Roger W. "Fundamental Price Behavior Characteristics in Commodity Futures." Futures Trading Seminar, II (Madison: Mimir Publishers, 1963).

[25] Hathaway, D. E. "Food Prices and Inflation". Brookings Papers on Economic Activity I, 1974.

[26] Hawtrey, R. G. "A Symposium on the Theory of the Forward Market: III. Mr. Kaldor on the Forward Market." Review of Economic Studies 7 (June 1940):196-205.

[27] Hicks, J. R. Value and Capital, 2nd Ed., Clarendon Press, Oxford, 1965.

[28] Hieronymus, T. A., Economics of Futures Trading. Commodity Research Bureau Inc., New York, 1971.

[29] Hieronymus, T. A. Uses of Grain Futures Markets in the Farm Business. Agricultural Experiment Station Bulletin 696. Urbana:University of Illinois, 1963.

[30] Himmelblau, D. M., Applied Nonlinear Programming. McGraw-Hill Book Company, New York, 1972.

[31] Hoffman, G. W., and Duvel, J. W. T. Grain Prices and the Futures Market:A 15 Year Survey, 1923-38. U.S. Department of Agriculture Technical Bulletin no. 747. Washington, D.C.: U.S. Government Printing Office, January 1941.

[32] Houck, James P. "A Statistical Model of the Demand for Soybeans." Journal of Farm Economics 46 (May 1964):366-374.

[33] Houck, James P. Demand and Price Analysis of the U.S. Soybean Market. Minnesota Agricultural Experiment Station Bulletin no.244, 1963.

[34] Houck, J. P., and Mann, J. S. Domestic and Foreign Demand for U.S. Soybeans and Soybean Products. Agricultural Experiment Station, Technical Bulletin 256, Minneapolis:University of Minnesota, 1968.

[35] Houck, James P. "The Relationship of Direct Price Flexibilities to Direct Price Elasticities." Journal of Farm Economics 46, (August 1964):789-792.

[36] Houthakker, H. S. "Can Speculators Forecast Prices?" Review of Economics and Statistics 39 (1957):143-151.

[37] Houthakker, H. S. Commodity Futures IV:An Empirical Test of the Theory of Normal Backwardation. Cowles Commission Discussion Paper, Economics No. 2124, (22 June 1955).

[38] Houthakker, H. S. "Free and Stable Commodity Markets." Statements to the National Advisory Committee on Food and Fibre. September 1966.

[39] Houthakker, H. S. "Restatement of the Theory of Normal Backwardation." Cowles Foundation Discussion Paper, No. 44 (18 December 1957).

[40] Houthakker, H. S. "Systematic and Random Elements in Short Term Price Movements." Proceedings of the American Economic Association 51 (May 1961):164-172.

[41] Houthakker, H. "The Scope and Limits of Futures Trading." In Allocation of Economic Resources: Essays in Honor of B. F. Haley, edited by M. Abromovitz, Stanford:Stanford University Press, 1959.

[42] Irwin, H. S. "Seasonal Cycles in Aggregates of Wheat Futures Contracts." Journal of Political Economy 43 (1935):278-288.

[43] Jenkins, G. M. and Watts, D. G. Spectral Analysis and its Applications, Holdar-Day, San Francisco, 1969.

[44] Johnson, Leland L., "The Theory of Hedging and Speculation in Commodity Futures." Review of Economic Studies 27 (June 1960): 139-151.

[45] Kapur, G. P. "Prices and Production in Agriculture." Indian Economic Journal 11 (April-June 1964).

[46] Kemp, Murray C. "Speculation, Profitability and Price Stability." Review of Economics and Statistics 45 (May 1963). 185-189.

[47] Kendall, M. G. and Stuart, A., The Advanced Theory of Statistics, Vol III, Hafner Publishing Company, New York, 1966.

[48] King, G. A. The Demand and Price Structure for By-Product Feeds. U.S. Department of Agriculture, technical bullentin no. 1183. Washington, D.C.:Government Printing Office, August 1958.

[49] Labys, W. C. and Granger, C. W. J. Speculation Hedging and Commodity Price Forecasts. Heath Lering Books, Lexington, Mass., 1970.

[50] Larson, Arnold. Evidence on the Temporal Dispersion of Price Effects of New Market Information. Ph.D. dissertation, Stanford University, 1960.

[51] Larson, Arnold B. "Estimation of Hedging and Speculative Positions in Futures Markets." Food Research Institute Studies 2(November 1961):203-212.

[52] Mandelbrot, B. "Forecasts of Future Prices, Unbiased Markets and 'Martingale' Models." Journal of Business Security Prices 39, Suppl. (January 1966):242-255

[53] McKinnon, Ronald I. "Futures Markets, Buffer Stocks, and Income Stability for Primary Producers." Journal of Political Economy 75 (December 1967):844-861.

[54] Meinken, K. W. et. al. "Measurement of Substitution in Demand for Time Series Data:Synthesis of Three Approaches." Journal of Farm Economics 38 (August 1956):711-735.

[55] Meinken, K. W. The Demand and Price Structure for Wheat. U.S. Department of Agriculture, Technical Bulletin no. 1136. Washington, D.C.:Government Printing Office, November 1955.

[56] Mills, E. S. Price Output and Inventory Policy. New York: Wiley, 1962.

[57] Mills, E. S. "The Use of Adaptive Expectations in Stability Analysis"; and Nerlove, M. "The Use of Adaptive Expectations in Stability Analysis--Reply." Quarterly Journal of Economics 75 (May 1961):330-338.

[58] Mosbeak, E. J. and Wold, H. O., Interdependent Systems: Structure and Estimation, American Elsevier, New York, 1970.

[59] Muth, J. F. "Rational Expectations and the Theory of Price Movements." Econometrica 29 (July 1961):315-335.

[60] Nerlove, Marc. "Adaptive Expectations and Cobweb Phenomena." Quarterly Journal of Economics 73 (May 1958):227-240.

[61] Nerlove, Marc. Distributed Lags and Demand Analysis for Agricultural and Other Commodities. U.S. Department of Agriculture, Agricultural Handbook no. 141. Washington, D.C.:U.S. Government.Printing Office, 1958.

[62] Nerlove, Marc. "On the Nerlove Estimate of Supply Elasticity." Journal of Farm Economics 40 (August 1958):723-728.

[63] Nerlove, M., "Spectral Analysis of Seasonal Adjustment Procedures", Report No. 6227, Econmetirc Institute, Rotterdam, The Netherlands.

[64] Nerlove, Marc, and Addison, William. "Statistical Estimation of Long-Run Elasticities of Supply and Demand." Journal of Farm Economics 40 (November 1958):861-880.

[65] Nerlove, Marc. The Dynamics of Supply:Estimation of Farmers' Response to Price. Baltimore:Johns Hopkins Press, 1958.

[66] OECD, Agriculture Policy in the United States, Organization for Economic Cooperation and Development, 1974.

[67] Paarlberg, Donald. Prices of Soybeans and Soybean Products. Agricultural Experimental Station Bulletin 538. Lafayette, Ind.; Purdue University, September 1949.

[68] Phillips, J. "The Theory and Practice of Futures Trading." Review of Marketing and Agricultural Economics (JUne 1966).

[69] Pulino, Leonardo A. A Recursive Model of the U.S. Domestic Soybean Market, Ph.D. dissertation, Michigan State University, 1966.

[70] Rockwell, Charles S. Profits, Normal Backwardation, and Forecasting in Commodity Futures, Ph.D. thesis, University of California at Berkeley, 1964.

[71] Samuelson, Paul A. "A Random Theory of Futures Prices." Industrial Management Review 6 (June, 1965).

[72] Samuelson, P.A., Intertemporal Price Equilibrium; A Prologue to the Theory of Speculation, Weltwirtshefthiches Archiv, December 1957.

[73] Samuelson, Paul A. "Proof that Properly Anticipated Prices Fluctuate Randomly." Industrial Management Review 6 (Spring 1965):41-49.

[74] Sargent, Thomas J. "Commodity Price Expectations and the Interest Rate." Quarterly Journal of Economics 83 (February 1969):126-140.

[75] Shepherd, Geoffrey S. Agricultural Price Analysis. Ames: Iowa State University Press, 1966.

[76] Telser, Lester G. "A Theory of Speculation Relating Profitability and Stability." Review of Economic Studies 41 (August 1959):295-301.

[77] Telser, Lester G. "The Supply of Speculative Services in Wheat, Corn and Soybeans." Food Research Institute Studies 7, suppl. (1967):131-176.

[78] Teweles, J., Harlow, C. V. and Stone, H. L., The Commodity Futures Trading Guide, McGraw-Hill Book Co. New York, 1969.

[79] Tobin, J. "Liquidity Preference as Behavior Toward Risk." Review of Economic Studies 25 (February 1948).

[80] United Nations, Food and Agricultural Organization: Production Yearbook, New York, 1962 - 1972.

[81] United Nations, Food and Agricultural Organization: Trade Yearbook, New York, 1962 - 1972.

[82] U.S. Department of Agriculture, Crop Production Reports, Prospective Plantings Report, and Annual Summary, 1961-196.

[83] U.S. Department of Agriculture, Fats and Oils Situation Reports, 1961-1972.

[84] U. S. Department of Agriculture, Food Grain Statistics. 1961 - 1972.

[85] U. S. Department of Agriculture, Grain Market News. 1961 - 1972

[86] U. S. Department of Agriculture, Margins, Speculation and Prices in Grains Futures Markets. Economic Research Service, Washington, D. C., December 1967.

[87] U. S. Department of Agriculture, The Feed Situation Report, 1961 - 1972.

[88] U. S. Department of Agriculture, The Quarterly Stock of Grain in All Positions Report.

[89] U. S. Department of Commerce, The Survey of Current Business, 1967 - 1972.

[90] U. S. Department of Agriculture, Wheat Situation Report, 1961 - 1972.

[91] Wold, H.O. "Nonlinear Estimation by Iterative Least Squares Procedures" in Festschrift for J. Neyman, John Wiley, New York, 1966.

[92] Wood, D.B. (ed) "The Use of The Earth Resources Technology Satellite (ERTS) for Crop Production Forecasts", draft final report of the Task Force on Agricultural Forecasting, Goddard Space Flight Center, July 24, 1974.

[93] Working, Holbrook. "A Theory of Anticipatory Prices." American Economic Review 48 (May 1958) : 188-199.

[94] Working, Holbrook. "The Investigation of Economic Expectations."

[95] Working, Holbrook. "Theory of the Inverse Carrying Charge in Futures Markets." Journal of Farm Economics, 30 (February 1948) : 1-28.

[96] Working, Holbrook, "The Theory of Price of Storage," American Economic Review 39 (December 1949 : 1)43-1262.

DRAFT

The following report is the result of a contract issued to ECON, Inc. of Princeton, New Jersey by the Office of Applications, NASA Headquarters, Washington, D.C. It is part of an ongoing effort on NASA's part to assess the value to society of the products of its research and development efforts.

This report assesses the economic value of information produced by an assumed operational version of an Earth Resources Survey System of the ERTS class. The period of assessment is from 1978 to 1993 and the information needs and technical capabilities are extrapolated to that period for the assessment of benefits.

It should be noted that the technical capability of an ERS system to forecast agricultural production was not addressed in this study. A NASA task force on agricultural forecasting performed a technical analysis of the theoretical capability of an ERTS Type system to provide improved agricultural forecasts in this time period, and ~~this~~ the capability derived in this analysis was ~~used as~~ a reasonable quantitative input to the economic models derived herein by ECON, Inc. The quantified benefits listed therefore are a product of the ~~given~~ assessment

used as

DRAFT

of

performance and the derived model of the economic value of improved information. Since the performance estimates are theoretical in nature the degree to which the ascribed benefits can be realized depends critically on the continued development of information extraction techniques and the limits imposed by large scale real world operations. Experiments are now in being which will clarify and define these limiting factors.

EK/RLSchweickart:jdr:12/11/74